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MAY 25 1951

The Dock & Harbour Authority

No 367 Vol. XXXII. MAY, 1951 Monthly 1s. 6d.

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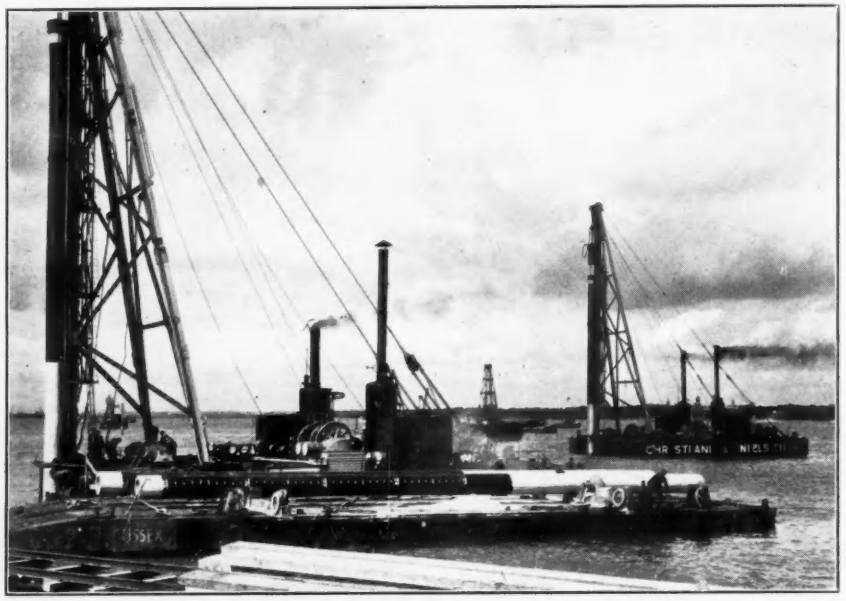

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The Dock and Harbour Authority

No. 367. Vol. XXXII MAY, 1951 Monthly 1s. 6d

Editorial Comments

THE IMPORTANCE OF OIL TO PORT AUTHORITIES.

On May 28th, the third World Petroleum Congress convenes at the Hague, under the Presidency of Jonkheer O.C.A. Van Lidth de Jeude, President of the Royal Netherlands Institution of Engineers. This congress which will be attended by some fifteen hundred delegates from over twenty different countries, including Great Britain, will be the third of its kind, the first being held in London in 1933 and the second in Paris 1937.

The reasons leading to the decision to initiate such periodical conventions were many, and included such objects as the furtherance of study of the science and technology of the petroleum and allied industries, upon an international scale, together with the provision of facilities for the scientists, technicians and engineers of many countries to exchange knowledge and information.

The Committee of Honour of the Conference includes government officials of the countries, representing such departments as economics and foreign affairs, industry and commerce, and the British Ministry of Fuel and Power. The Permanent Council of the Congress is equally international, while the organising committee of the forthcoming Conference is composed of members of the petroleum section of the Royal Netherlands Institution of Engineers, and representatives of the oil industry in Holland.

The value of an international petroleum congress at which all the many specialised sciences and techniques embodied in the operations of the oil industry could be discussed, was clearly indicated by the success which attended the previous congresses. In such a vast and complex enterprise as the modern international oil industry, depending, as it does, so essentially upon progressive scientific technology in all its spheres, opportunity for experts to report on the latest developments is of the greatest value to the efficiency of the industry as a whole. The wide range of subjects to be considered at the forthcoming congress indicates the importance of the industry to the modern world. In addition to specific papers and discussions, delegates will hear four general lectures covering all problems concerning oil production, and will also have the opportunity of visiting local installations and industrial plants.

To focus attention upon the great and growing importance of oil in world economics and the part played in its production therein by science and engineering, the oil industry of the United Kingdom has organised a series of exhibitions at certain University centres. The first was held in London last month and the others follow at Glasgow, Leeds and Cambridge. It is fitting that these events should take place during the Festival of Britain year, since oil more than any other factor has been responsible for the remarkable developments of the present century.

We are publishing this month an article which briefly reviews some of the varied shipping facilities and oil handling installations which have been recently completed in many parts of the world. As our correspondent points out, oil and its derivatives now form the largest single item in the world import and export trade, and the rapid and safe handling of oil at ports has become a matter of great importance in view of the phenomenal increase in oil consumption which has taken place in recent years.

Most industrial countries are remote from natural sources of oil and therefore depend upon sea transport for their supplies, and to keep pace with the growing demand, they are continually finding it necessary to increase their oil handling facilities. Also as the oil reserves are, in many instances, situated in regions lacking adequate port accommodation, the oil companies are faced with the necessity of making good the deficiency by building entirely new ports or else augmenting such facilities as already exist.

Perusal of the article will give an indication of the magnitude of the task facing the oil industry in keeping the world supplied with one of its most vital commodities.

GOVERNMENT'S NEW OUTLOOK ON TIMBER.

Speaking in the House of Commons recently, on the Budget Proposals and Economic Survey, the President of the Board of Trade, said the Government would be prepared, as far as it could, to substitute timber for particular types of steel as they became short in essential industry. He pointed out that thanks to an appreciable volume of buying in Europe, by importers, the timber stock position in this country looked like being better than for a very long time past. He indicated, however that, although imports of timber, including softwood, were on the increase, there remained a necessity to accumulate large stocks of timber before any general increase could be permitted to industry and trade.

This is a complete reversal of the policy of the last twelve years, during which the tendency has been to substitute steel and concrete for timber, which, owing to the incidence of war, has been in short supply. Now a shortage of steel and cement, much of which will be channelled into factories working on armament orders, will have to be made good by the use wherever possible of other materials; among which timber will be one of the most important.

Since 1936 great strides have been made in the progress of timber technology, mainly through the work of the Timber Development Association and the Forest Products Research Laboratory, Princes Risborough. When the Festival of Britain was being planned the designers, recognising the importance of wood as a raw material, approached the former for their assistance, and as a result of their co-operation, several revolutionary uses of timber can been by visitors to the exhibition. There are the five laminated wooden arches, 68-ft. high and 100-ft. wide, which we have previously referred to in these columns and the seven

Editorial Comments—continued

smaller arches supporting the stressed skin plywood dome which forms the roof of the Royal Reception Suite. The Royal Festival Hall also contains many examples of the use of timber, for the whole of the decorative effect is obtained by using timbers from all parts of the world.

PORT HEALTH AND SANITARY CONTROL.

During the past two weeks, visitors from the Netherlands, Belgium, Italy, France, Portugal, and British Guiana have been studying the fumigation of ships, ways of dealing with rodents in docks and vessels, and systems of examining imported foodstuffs, at a course on " Port Health and Sanitary Control " which opened in London on April 23rd, under the auspices of the British Council. The visitors included the Head of the Maritime Sanitary Service, Antwerp; the Head of the Department of Hygiene and Health in the French Ministry of the Merchant Marine; a Senior Government Sanitary Inspector from Georgetown, British Guiana; and the Medical Officer of the Port of Lisbon.

Ship inspection and rat control provided the main interest during a visit to the India Dock Group, and visits were also made to the Gravesend Boarding Station and Isolation Hospital. A lecture demonstration on the inspection of imported foodstuffs was given during the visit to the Royal Group of Docks, and subsequently the party inspected modern rat-proof warehouses at the Surrey Docks and saw a ship being prepared for fumigation. The course was then transferred to Liverpool for a further week's programme which will conclude on May 4th.

In London the course was under the direction of Dr. M. T. Morgan, Medical Officer of Health for the Port of London, and Dr. E. R. Peirce, Senior Assistant Port Medical Officer, is in charge of the programme in Liverpool, which has been arranged in conjunction with the Port Health Authority and the Mersey Docks and Harbour Board.

The depredations of rats upon the food supplies of the world are a serious menace, and also a danger to health, as these vermin are notorious carriers of infectious diseases. While it is extremely doubtful whether they will ever be exterminated, it is only by concerted and continual efforts in the rat-proofing of both ships and warehouses that the rodent population in docks can be kept within reasonable limits. Much has been done in this respect in some countries, particularly in America, and the present international examination of the subject, with a view to co-ordination of methods and efforts, is a welcome advance.

IMPROVEMENTS AT THE PORT OF MADRAS.

For some time past consideration has been given to plans for the improvement of the Port of Madras, and we have now been informed that the present position regarding the Harbour Extension Scheme is that the Government of India has accepted an outline plan showing the direction in which the Port should develop, and the general layout of a new tidal dock comprising ten berths with double-storied transit sheds, warehouses, sidings and a large marshalling yard.

The scheme provides for the work being carried out in stages; the first stage, which will probably suffice for the trade of the Port for many years to come, provides for the construction of four berths with four double-storied transit sheds, sidings and marshalling yard, estimated in 1946 to cost, with equipment, roughly 3½ million pounds sterling. Unfortunately, everything pertaining to this scheme is held up until arrangements can be completed for financing the project. In the meantime, detailed drawings are being prepared and the Trust's Consulting Engineers, Messrs. Rendel Palmer and Tritton, will shortly be called in to advise on the technical aspects of the project after which a more accurate estimate will be prepared.

The Trust has had a small pilot model of the Harbour constructed at the Hydraulic Research Station at Poona to ascertain how far it is possible to suppress wave action in the Harbour during cyclonic storms, and also in the proposed new tidal dock. As soon as certain wave measuring apparatus has been received from England, experiments will begin.

The sand problem at Madras, which has become very acute in the last two years owing to dredging equipment being lost during the war, is now being actively investigated and in addition to starting a project to lengthen the sand screen by 400-ft. which was referred to in an article in the October 1927 issue of this Journal, the Trust has a sand pump mounted on a travelling chassis which operates along this groyne, removing sand from the " trap " and pumping it into a dredger lying inside the Harbour for dumping at sea. If it can be proved that the shallower contours towards the Harbour Entrance can be controlled by this sand pump, a battery of similar pumps will be purchased in due course.

INTERNATIONAL HEALTH SERVICE FOR SEAMEN.

In an article in the current issue of the *International Labour Review*, the official organ of the International Labour Organisation, Dr. Karl Evang, Director-General of the Norwegian Health Service, stresses the necessity for further international action in dealing with seamen's health needs.

Dr. Evang contends that the health and welfare conditions still existing among seamen who travel from port to port in all parts of the world, are a threat to maritime nations as well as to the seamen themselves, and despite the advances made since 1920 through the adoption of international conventions governing conditions at sea, a number of problems remain acute. Among these, he points out that every port is subject to the visits of seamen who may be suffering from various infectious and contageous diseases and a modest outlay for an international health service would ensure a lessening of the dangers of infection to persons ashore.

From the seamen's point of view, there is a corresponding need for adequate hospital facilities, staffed with competent doctors and surmounting language barriers, as at present, many seamen fall into the hands of unscrupulous physicans. Among the mental conditions faced by seamen is alcoholism, and although they consume less liquor than many groups on land, much of the drinking is concentrated during the short periods in port, resulting often in the necessity for medical aid. Again, as he has to live for long periods in a unique and often disturbed environment, he is subject to individual mental stresses and to a conviction that he is isolated and unwanted. Living and welfare facilities ashore are therefore a further consideration, as too often, seamen are faced with a lack of decent accommodation, and of reasonable access to recreation or sports.

Dr. Evang urges that the time has come to consider seriously the creation of an international health service for seafarers in all major ports, and suggests three possible methods for bringing this about: firstly, by extending the Brussels agreement of 1924 to cover the treatment of all diseases; secondly, by establishing international medical offices through co-operation between the Governments of the maritime countries concerned, under the auspices of the World Health Organisation and the I.L.O.; and lastly, by establishing international medical offices through co-operation between shipping interests in the various maritime countries.

There are, of course, several Seamen's Aid and Welfare Societies in existence, with organisations in many ports, which have been doing excellent work all over the world for many years. Their efforts, however, are limited, and there will therefore be general agreement with the wide aims of Dr. Evang, who regards his second proposal, which would have to be self-supporting, as the " best and most natural solution " to the problem.

THE ADMINISTRATION OF THE PORT OF SUVA.

It was recently announced that a committee has been established to examine and make recommendations on the desirability of setting up a port authority to administer the port of Suva, Fiji Islands. The committee, which is under the chairmanship of Mr. D. A. Butler, manager of the Union Steamship Company of New Zealand, includes, among other interests, two nominees of the Suva Chamber of Commerce and two of the Indian Chamber of Commerce. It will make recommendations on the functions and powers of the port authority, its composition, the organisation required, and the relations of the Authority to the Government and local authorities.

It is interesting to observe the world-wide tendency towards the establishment of Port Authorities based on the British model of composite representation.

Oil Port Developments

A Review of some Recent Installations*

By W. J. HARRIS

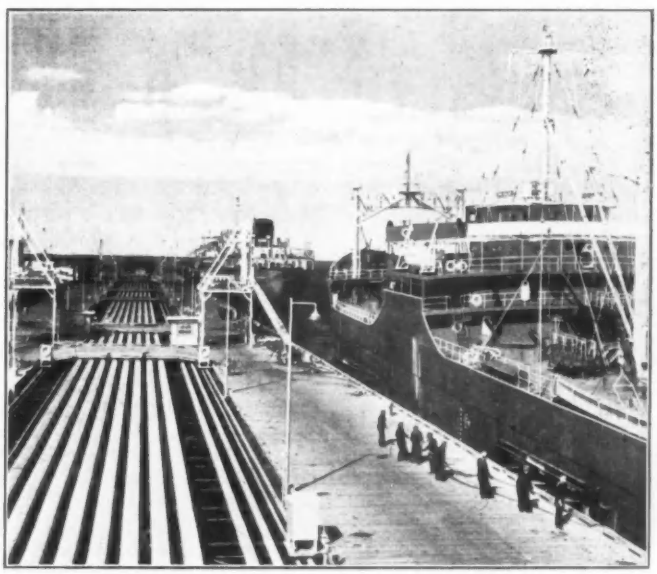
IT would be gratuitous to remind any connected with the administration of ports or harbours of the importance of oil in international commerce. For apart from the revenue derived by harbour authorities from the ubiquitous oil tanker and the important developments which have taken place in those dock areas where bulk oil installations are maintained, oil is the main basis for marine power and its derivatives now form the largest single item in the world's import/export trade. In 1949, latest year for which all available figures are available, no less than 143 million metric tons of oil and oil products entered into this traffic as against 126 million metric tons of coal, the second largest item. The facilities which dock and harbour authorities have provided in Britain to take care of this comparatively infant industry, upon which the world so greatly depends, are indeed widely appreciated. But what is not so generally known is the vast extent to which the oil industry overseas has itself had to embark upon the construction of harbour facilities, a contingency which has arisen because some of the world's most prolific oilfields are located in areas devoid of port facilities and where local resources have proved inadequate for undertaking major constructional developments. A survey of some of these overseas developments in the realm of terminal facilities may therefore prove of interest to readers who, because their lives centre around the ports and harbour facilities in Britain or other highly developed countries, may like to have some picture of the other end of the tankers' journey.

THE PORT OF KUWAIT

An outstanding recent example of an overseas oil terminal is to be found in the Mena al Ahmadi installation at Kuwait. This tiny sheikdom, lying at the head of the Persian Gulf, is hardly larger in size than the county of Yorkshire. But its famous famous Burgan oilfield, brought into commercial operation in 1946, has proved one of the most prolific oilfields in the world. Its annual output has increased from 2 million metric tons in 1947 to an estimated 17.2 million metric tons in 1950 and it became evident from the earliest days of the field's operation that substantial shipping facilities would eventually be required. Initially, oil was loaded aboard tankers by means of submerged pipelines running from shore to a tanker anchorage about a mile from low-water level, ten 12-in. diameter lines being connected in pairs to five tanker pick-up points. It soon, however, became apparent to the oil company concerned that the most satisfactory long-term solution would be the construction of a well-equipped permanent port at which not only tankers but general cargo could be accommodated. This project was put in hand in 1947, the work was entrusted to Bechtel International and its associates, the lay-out being designed by Sverdrup and Porcel, a Bechtel affiliate, Wilton H. Gerhart being the chief engineer.

The design provided for a main pier, 4,140-ft. long and 49½-ft. wide, ending in a T-head, the north and south arms of which form the oil and general cargo quays respectively. The main pier incorporates a road, 24-ft. wide, and a pipeline system which includes eight 24-in. diameter crude oil pipelines, a 16-in. pipeline for heavy bunker fuel and a 12-in. pipeline for diesel fuel. Other, smaller lines carry additional fuels, sea and fresh water and compressed air. A concrete "anchor" secures the pipelines, which are laid on rollers to allow for movement under expansion and contraction, to the shore terminal of the pier.

The oil quay is 2,805-ft. long and 105-ft. wide and can accommodate six tankers of any size, up to largest in commission (at present just over 30,000 deadweight tons); loading being carried out at the rate of 70,000 tons of crude oil per berth per 24 hours. The general cargo quay, 1,077-ft. long and 100-ft. wide, is linked to the main pier by a road running out diagonally from pier to quay, the purpose of which is to enable lorries to reach the cargo berths without passing the actual T-head and the vicinity of the oil quay. At the T-head are located the various administrative buildings—offices, an air-compressor station, pump houses, etc. and a recreational room for crews of visiting ships. Four 5-ton Portal cranes and a 60-ton derrick have been installed on the general cargo quay and six derricks for handling hoses on the oil quay.



General View of Oil Jetty at Mena Al Ahmadi, Kuwait.

CATHODIC ANTI-CORROSION SYSTEM.

Safeguarding against corrosion is always a special consideration in the waters of the Persian Gulf owing to their destructive reaction on metal, and it was therefore decided to supplement the protection afforded the steel piles from their coaltar coating, with an electrical cathodic system. Magnesium anodes were set in the sea adjacent to the piles and the latter themselves turned into cathodes by connection via a current limiting resister. The sea water — the electrolyte — is reacted upon this current and the hydrogen ions deposited upon the piles to form an anti-corrosion skin. The only necessary maintenance is the replacing of the magnesium anodes as and when these become eaten away.

FENDER DESIGN.

Another interesting innovation embodied in the port is the design of the fenders used to prevent damage to the quays from ships coming alongside. Their design is one originally evolved by Professor A. L. L. Baker, of the Imperial School of Science, London, and used with great success in equipping Britain's D-day "Mulberry Harbour." Slightly modified for use at Kuwait, where violent storms are by no means uncommon, these fenders consist of sets of three steel cylinders, each 6-ft. in diameter and 21-ft. in length. The cylinders are filled with concrete and faced with timber baulks, then mounted on a mechanism which enables

*On May 28th, the third World Petroleum Congress meets in Holland to consider all the ramifications of the modern international oil industry. This article reviews briefly the development of specialised shipping facilities necessary in the handling of crude oil or finished products.

Oil Port Developments—continued

them to ride away from the thrust of a vessel. Forty-four sets have been built into the pierhead at intervals of 135—165-ft.

HARBOUR WORKS.

Kuwait's tempestuous climate also required the erection of a harbour next to the pier, where the fleet of tugs, supply barges and other necessary small craft could find sheltered anchorage. Over 130,000 cubic yards of stone were quarried locally for construction of the breakwater, and dredging—still in progress—will mean the ultimate removal of 250,000 cubic yards of sand, silt and coral from the harbour bed. A 600-ft. quay, on the same principle as the main pier, has also been built.

Named after the late Sheik of Kuwait, who was himself deeply interested in the project, Mena al Ahmadi is not only the reputed largest installation of its kind in the world, but is a striking testimony to the need imposed upon the modern international oil industry to create its own ancillary facilities wherever necessary, despite all difficulties entailed.

THE PORT OF BEIRUT

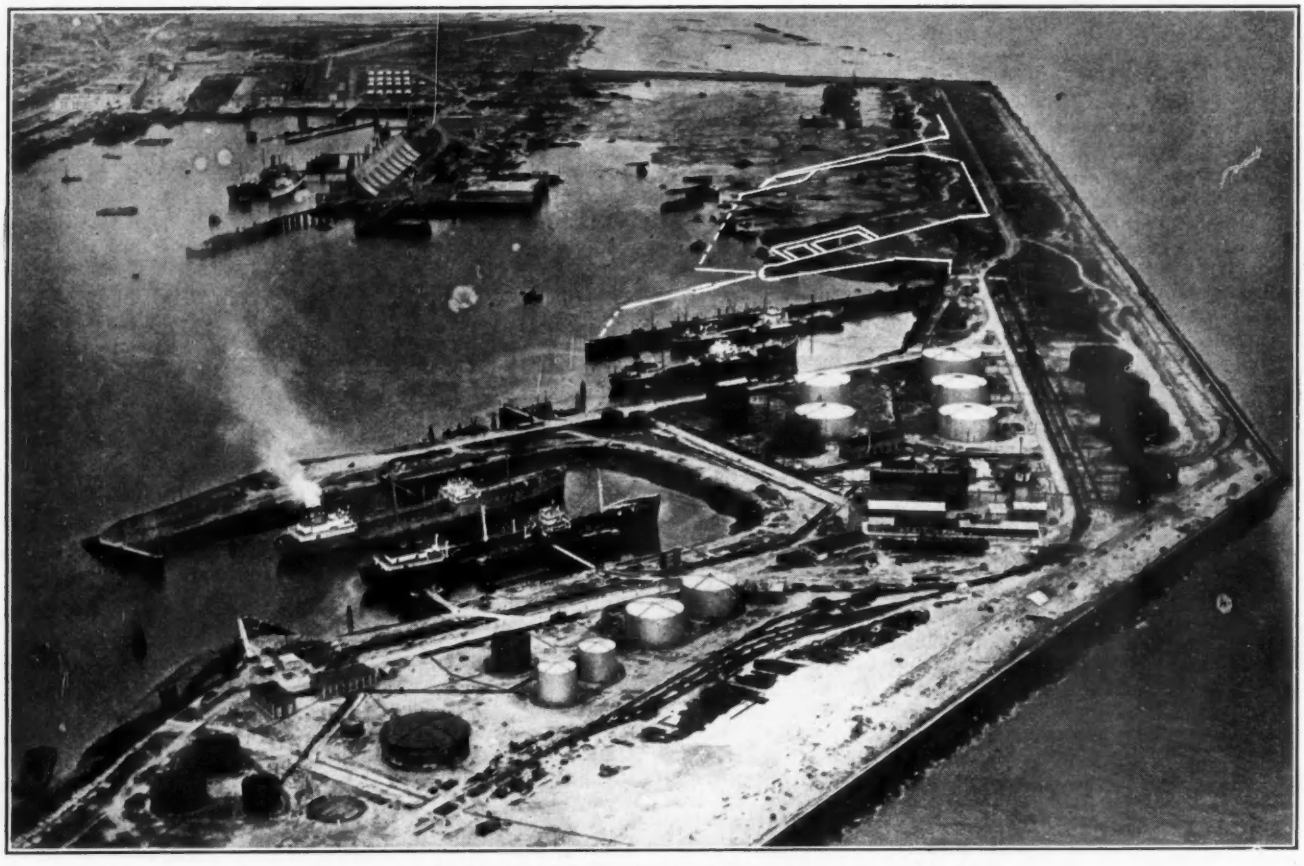
Mena al Ahmadi is by no means the only new tanker terminal recently constructed in the Middle East. Simultaneously with the building of the Kuwait installation came the building of another outstanding project — the Trans-Arabian pipeline system — designed to link the Saudi Arabian oilfields in the region of the Persian Gulf with a Mediterranean shipping point. Since there are no harbours along the eastern Mediterranean coast with any natural protection, and since the new port of Beirut, although protected with a breakwater, has only a small harbour, unsuited for large-scale development, the constructors of the Trans-Arabian pipeline has no assistance from either natural or artificial sources in building their tanker depot. As at Kuwait, it was a matter of starting from scratch.

The site finally chosen was an open stretch of coastline some four miles south of the ancient Biblical port of Sidon. It has a frontage of 5,700-ft. and extends inland for 5,800-ft. The tanker roadsteads cover an area of approximately 2 miles in length and $1\frac{1}{2}$ miles in width. Four offshore loading berths have been constructed, each a mile from low-water level and with a clearance space of 2,600-ft. between each berth. Water at the berths is between 50—55-ft. deep.

STORAGE TANKS AND PIPELINES.

It may be of interest here to cite a few facts concerning the storage tanks comprising the terminal " farm " if only to give some indication of the size of the installation. There are at present thirteen floating-roof crude oil storage tanks, each 164-ft. in diameter, 50-ft. high, and with a capacity of 25,000 metric tons; two fuel-oil storage tanks and one emergency tank, all of 25,000 tons capacity; and three 2,000-ton capacity fuel-handling tanks. The sixteen large-capacity tanks have been built of heavier than usual materials, their steel plates being $\frac{7}{8}$-in. thick at their base and $\frac{1}{4}$-in. thick at their top. Their bases stand on asbestos-fibre packing, treated with a preservative coat. Three miles of 30-in. diameter incoming pipelines feed the crude oil storage tanks, while 10 miles of 30-in. diameter crude oil pipelines and 10 miles of $12\frac{1}{4}$-in. to 18-in. fuel-oil pipelines run from the tanks to the shore, where the submerged loading and unloading lines come into action. The latter comprise 2 miles of 30-in. and 2 miles of 20-in. crude oil loading lines, and 4 miles of $12\frac{1}{4}$-in. to 18-in. lines for receipt or delivery of fuel oils.

To regulate the oil flow to and from the various tanks, two manifold controls have been built—one sited at the storage farm and the other on the shore—which together manipulate over 130 large valves. Extreme accuracy in directing the flow is obtained by means of an advanced method of electrical valve manipula-



Aerial View of the Port of Le Havre showing site of proposed new oil basin.

Oil Port Developments—continued

tion, and an elaborate system of signal bells and lights warns operators in the control rooms when high or low level in any tank is being approached. Since the crude oil storage tanks are situated on the crest of a slight hill their content can be loaded by means of gravity alone without assistance of pumps. The fuel-oil tanks, standing on level ground near the shore, are serviced by four 260 h.p. diesel pumps

Before laying the four 1-mile lengths of submerged crude oil loading lines, the pipe itself was cleaned, primed, treated with asphalt, encased in glass matting, again treated with asphalt, recased with asbestos felt and finally wrapped with asphalted heavy asbestos fibre. To prevent the strong submarine currents from swinging the lines out of place they are secured in position by concerte blocks, spaced at 250-ft. intervals. When these were being lowered, a diver descended with each until it swung just clear of the sea bed. Then, by means of telephoned instructions to the ship above, he directed the exact final siting of the block.

Each of the four loading berths is equipped with five steel mooring buoys, the latter being anchored by 540-ft. lengths of chain to two 5-ton Danforth anchors. The chain is $2\frac{7}{8}$-in. in diameter and weighs 80 lbs. per foot. During loading operations ship-to-shore communication is established both by radio and telephone, and the combined loading rate of all four berths is up to 288,000 tons per 24 hours.

As a matter of general interest, it may be mentioned that the Trans-Arabian pipeline project, which cost the dollar equivalent of over £75 million, came into operation at the close of 1950 and the first consignment of oil from the Sidon terminal to reach Britain arrived at its Hampshire destination in January last.

THE PORT OF LE HAVRE AND OTHERS

In Europe, where numerous oil import development schemes are taking place, including several major projects in Britain, an especially interesting expansion scheme is being carried out at Le Havre. Here, a complete new installlation has been undertaken to cope with the tremendous increase in the volume of oil handled — 4,400,000 metric tons in 1948 as against 3,800,000 metric tons in 1938 with an expected 7 million tons in 1953. This new port has been designed to accommodate tankers up to an eventual 45,000 d.w tonnage and the measurements of such vessels have been anticipated as being an overall length of 680-ft., a width of between 95 and 100-ft., and drawing some 36-ft. of water. The Le Havre authorities are anxious that it shall be possible to turn round the largest tanker ever likely to be built within approximately 30 hours of her tying up, and accordingly provision is being made for the simultaneous unloading of oil cargoes and the handling of general ship's supplies. Port cranes will supplement the tanker's derricks in order to speed the turnround.

An integral part of the scheme has been the dredging of the port entrance to ensure an adequate depth of water for large tankers to arrive or depart, irrespective of the state of the tide. Safety precautions also figure prominently in the new port's design. Remembering the lesson learned in December 1946, when a laden tanker pulled loose her moorings in the middle of the night, all bollards in the new berths have been constructed to withstand a strain of 100 tons at their tops. Another precaution is the provision of floating booms at the entrances of both the main basin and of an adjoining, smaller basin, intended for coastal tankers and fuel barges. The purposes of such booms is, of course, to isolate a basin should a fire occur and prevent the flames spreading across the surface of the water to reach other parts of the port.

Another interesting new oil port—on the Grand Isle coast of Louisiana, U.S.A.—was built in 1947-8 to handle oil being produced from an underwater well, drilled seven miles out to sea in the open Gulf of Mexico.* The port in question stands on what was formerly a virgin strip of sand dunes, and before beginning construction of the installation, the oil company concerned had first to fill in a large area of the site in order to raise it above flood-water mark. The port now comprises not only a jetty, oil-storage and fuel tanks and similar installations, but modern houses, shops, schools, medical facilities and all other amenities of a self-supporting community.

*This was the subject of an article in " The Dock & Harbour Authority " of June, 1949.

Off-Shore Drilling from Platform in the Gulf of Mexico.

FACILITIES FOR ICELAND

The first submarine pipeline to be laid off the Icelandic coast was recently put into operation at Shell's oil storage depot at Skerjafjord in the south-west corner of the country. Used for the discharge of petroleum products from visiting ocean-going tankers, which are prevented by shallow waters from approaching nearer than 700-ft. to the 1,000-ft. long oil pier, it replaces a floating pipeline which has done service for the past twenty-three years. The floating line had two disadvantages, considerable work was involved in running it out and bringing it back every time a tanker discharged its cargo, and the pipeline was often in danger in bad weather, particularly in winter when there ice on the fjord. The new submarine line will not only ensure a more efficient oil supply service to Skerjafjord but will treble the rate of discharge—300 tons an hour instead of 100 tons as previously.

The submarine pipeline is 8-in. in diameter and about 800-ft. long. It arrived from the U.K. in 27 sections protected with asphalt coating. The sections were welded together ashore into one complete line which was then towed out on high tide, filled with sea water and sunk to the sea-bed in its permanent position.

Heavy submarine type rubber hoses are fitted to the sea end of the line and fastened at the closing flange end to a marker buoy. When a tanker arrives it merely has to pick up this end hose from the buoy and connect it to its discharging lines. When discharge is completed, the hose is closed by a flange and sunk again beside the buoy ready for use by the next tanker.

This new line will make an important addition to the existing facilities at Skeriafiord, from which oil products are supplied to Reykjavik (the capital) and the South-West part of the country.

NEW FACILITIES AT ALGIERS

A new marine bunker installation on the Jetee de l'Est, Algiers, which can deliver bunker fuel to ships alongside at a rate exceeding

Oil Port Developments—continued

General View of the Refinery at Cardon.

1,200 tons an hour, was opened two years ago, and it is claimed that, with the aid of existing dumb barges acting as auxiliaries, each of which can pump at a rate of 500 tons an hour, the new installation's dispatch services are unequalled anywhere in the world.

The building of the depôt which was started in May, 1946 and was ready for operation in July 1948, presented a variety of constructional problems. These had to take into account the relatively restricted space of the site, and its isolation in the harbour, cut off as it was from direct communication with the mainland. To satisfy these demands, the depôt was built in such a way as to consist of seven squat tanks of 4,000 tons each, whose height barely exceeded the sea wall of the jetty. A boiler house complete with steam and electric pumping facilities was designed to enable tankers to discharge up to 1,400 tons an hour.

This modern installation which allows the largest tankers to be accommodated alongside, replaces a floating station for the supply of bunker fuels which was first mooted in 1914. It was not until 1920 however that the first vessel of 800 tons was introduced, and this was subsequently replaced by a hulk of 5,000 tons. Between 1920 and 1936 the floating depôt grew in varying stages, finally consisting of the hulks of two tankers, and two dumb barges, with a total capacity of 18,600 tons.

Due to the greatly increased demand for bunkers at Algiers and the growing size of tankers, it became evident that a land installation was required. While the first official approach to the authorities was made in May 1937, proposing the substitution of the floating depôt by a land installation, the intervening period of the second World War temporarily stopped proceedings. These were resumed in Oct. 1943 and closed successfully in Nov. 1945.

NORTHERN VENEZUELA

The already substantial capacity of the Cardon Refinery, Northern Venezuela—now producing some 3½ million tons of various oil products a year—is to be doubled by 1952. Work on the additional facilities—comprising another large crude distillation unit and modifications to the existing unit—is to begin in the early part of this year. The new extensions will mark another stage in the growth of this refinery, one of the world's most modern, that has been erected by Shell, in the face of great difficulties, on a once barren and windswept tract of land on the South-West corner of the Paraguana Peninsula.

Up to the present, the Cardon project has cost nearly £50 million, and has entailed the working of over 60 million man-hours and the consumption of more than 200,000 tons of steel. In addition to the plants already in operation, there is now nearing completion a modern installation for the production of over 100,000 tons a year of high quality lubricating oils which will serve a very wide range of purposes including aviation, automotive and diesel engine lubrication.

One of the most difficult problems at Cardon has been water supply which, on the peninsula, is virtually non-existent. Until recently, all fresh water for industrial and domestic purposes had to be imported by tankers, whilst drinking water was obtained by sea water distillation. Now, an 80 mile pipeline brings fresh water for all purposes from springs and water wells at Siburua situated in the foothills near Coro, on the mainland.

A unique feature at Cardon is the almost exclusive use of electricity as a source of motive power. A large power station at present operating with three 7,500 Kilowatt generating units will shortly be completed with the addition of a further unit of the same size.

Harbour facilities comprise two reinforced concrete jetties each of which is about 1,500-ft. long, at which four large ocean tankers and four smaller tankers can be berthed.

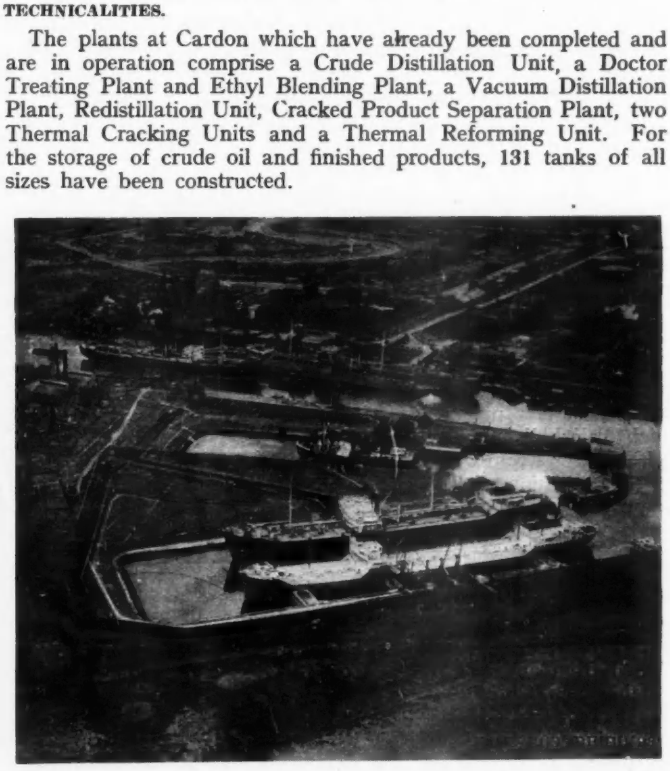
The refinery, the industrial area and the residential sector occupy an area of over 3,000 acres. In the industrial area there is a large modern office building and a well-equipped laboratory where extensive research is carried out on refining processes and new products. More than 4,000 different articles, ranging from costly air compressors to a drawing pin, are stored in the extensive warehouses which it is necessary to maintain for an installation of the size of Cardon.

The residential area, capable of accommodating 10,000 people, now that water is no longer a problem, is being transformed from a dry cactus-studded stretch of sand into verdant and productive gardens and lawns. All the houses are of the permanent bungalow type and are built of bricks manufactured at Cardon, with, in many cases, steel frames, roof trusses and windows.

Self-sufficient in almost every way, this small city boasts two modern schools, one for Venezuelan children and the other for foreign children, a hospital with 80 beds equipped with the most modern appliances, Roman Catholic and Protestant churches, an open air cinema, an extensive commissary building where certain articles are sold at controlled prices, a modern clinic for outpatients, a large restaurant, a pharmacy, a bakery and other miscellaneous shops. The present hospital will be replaced shortly by a new buliding specially designed for the purpose, by well known architects and the present building will be taken over for use as a second school for Venezuelan children.

TECHNICALITIES.

The plants at Cardon which have already been completed and are in operation comprise a Crude Distillation Unit, a Doctor Treating Plant and Ethyl Blending Plant, a Vacuum Distillation Plant, Redistillation Unit, Cracked Product Separation Plant, two Thermal Cracking Units and a Thermal Reforming Unit. For the storage of crude oil and finished products, 131 tanks of all sizes have been constructed.



Aerial View of Stanlow Oil Docks, Manchester Ship Canal.

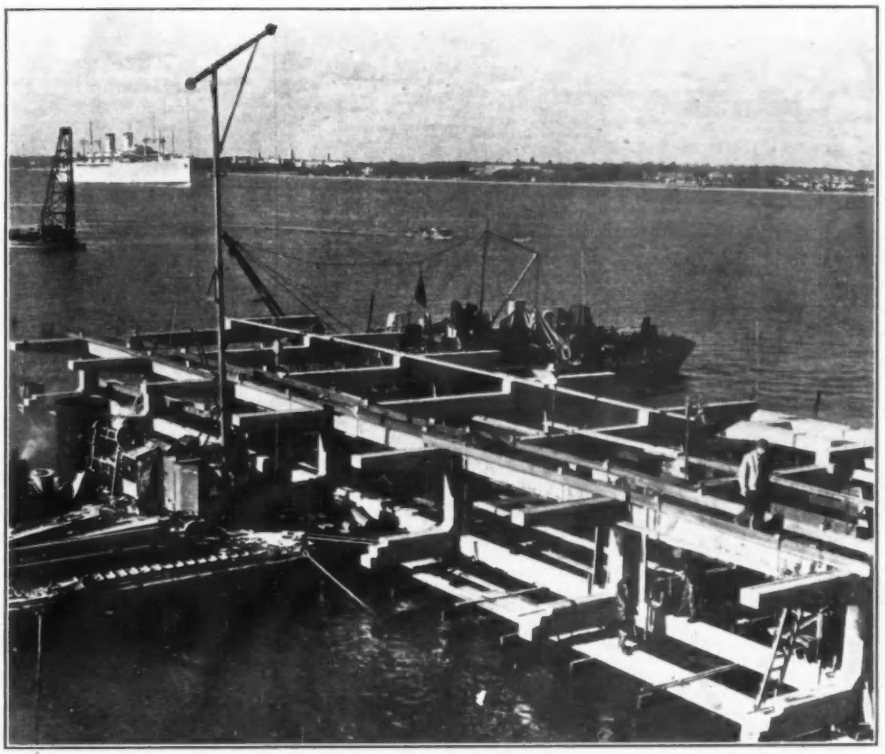
Oil Port Developments—continued

The lubricating oil plant, which is now nearing completion, will be extremely flexible in operation and will comprise the following units:—(a) Propane de-asphalting, (b) Furfural extraction, (c) M.E.K./Benzol de-waxing, (d) Clay contacting.

The intake will consist of Venezuelan reduced crude oils, both of the mixed base (paraffinic) and the naphthenic (non-paraffinic) type. Facilities for blending, packing and filling will also be provided.

OTHER VENEZUELAN INSTALLATIONS.

There are many other ports enjoying a new importance and new prosperity, either shipping or receiving oil, as a result of the international oil industry's recent expansion. Puerto La Cruz, for example, has during the last ten years blossomed from a little-known Caribbean coastal town into one of the most important oil shipping ports in the western hemisphere and its population has risen from 5,000 to 35,000 within this period. Maracaibo is another Venezuelan port where constant development for exporting oil is taking place, the latest factors here being the building of a long breakwater and a new pier, plus an extensive dredging programme.

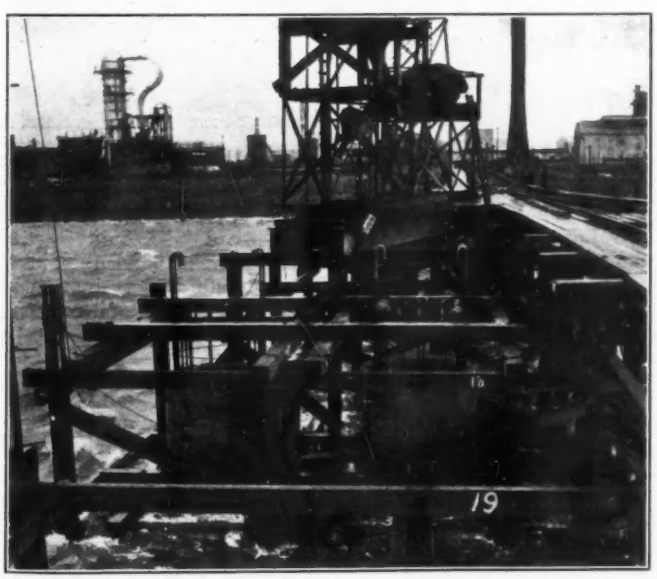


Work in Progress at Fawley. Assembly of precast frames in main Jetty which will carry pipes at two levels of the frame and a roadway on right.

NEW UNITED KINGDOM OIL PORTS

It may also be of interest to recall a few details concerning new oil ports being constructed within the U.K. For example, in October last, work began on the £4 million project for the provision of a new oil dock on the Manchester Ship Canal at Eastham—for which purpose a 175-acre site has been allocated. The design provides for four berths in the form of a square, each berth being able to accommodate a tanker of up to 30,000 d.w. tons. The entrance lock will be 800-ft. long by 100-ft. wide, whose three gates or caissons—being made by Messrs. Vickers Armstrongs at Barrow-in-Furness—will operate electrically instead of hydraulically, as is the case with the present Eastham lock gates.

Although the scheme entails the excavation and dumping of huge quantities of spoil, especial forethought has been given to avoiding any disturbance of local amenities. The dumping itself is being carried out on three deposit grounds which it is afterwards intended to soil to a depth of 18-in. for agricultural cultivation. Estimated total quantities of materials involved include 250,000 cubic yards of concrete and 6,000 tons of steel. Wherever an exact finish and an especially durable surface is required—as at the corners of the lock cambers—granite facing is being used.



Thames Haven Oil Jetty. View of Jetty from the head, showing R.C. cylinders being sunk to form foundations on river bed.

INSTALLATION AT FAWLEY.

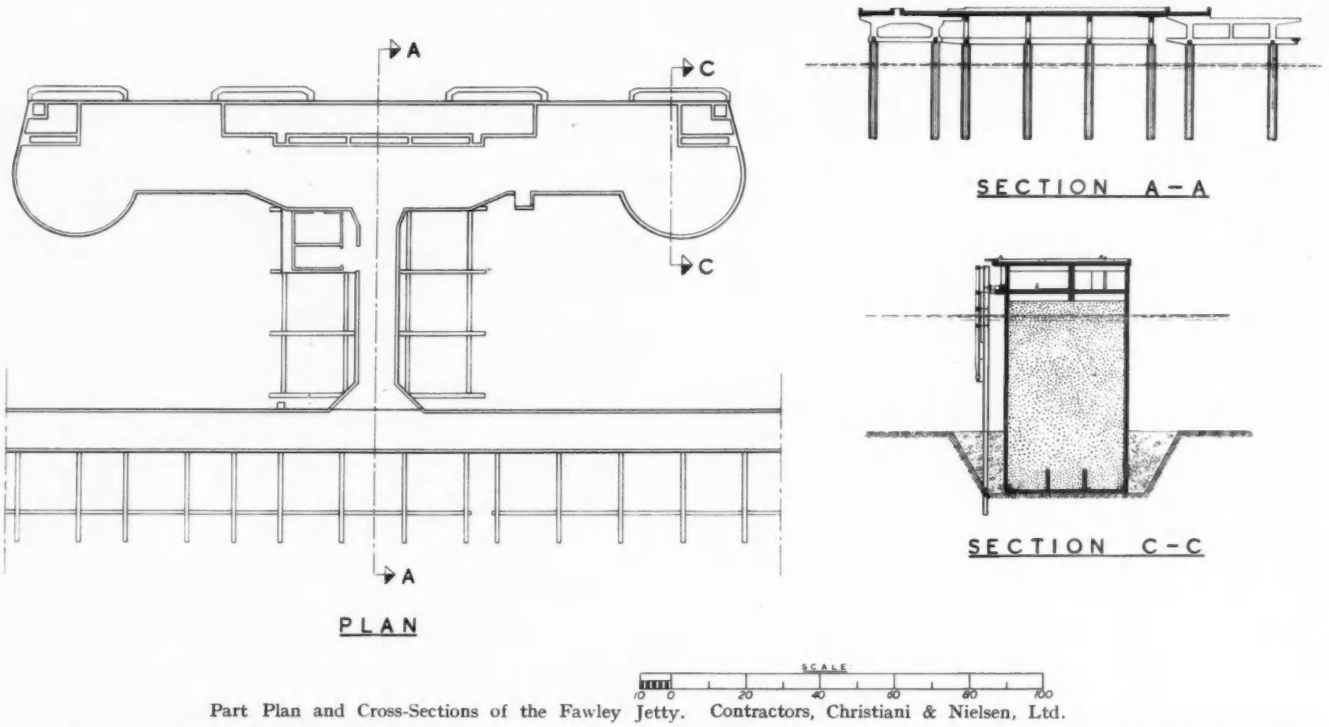
At Fawley—where the biggest refinery in Europe is being built at a cost of £37,500,000—another large new tanker installation is taking shape. The principal characteristics of this location are a safe and sheltered anchorage (60—70-ft. Low Water Ordinary Spring Tide) and a normal minimum depth of water in the navigable channel between the anchorage and the Fawley tanker terminal of 36—38-ft. The new docks will be basically designed for 26,000 d.w tons tankers, though consideration is being given to so spacing berths that larger tankers up to 700-ft. can be accommodated if and when necessary. Owing to the isolated and sheltered nature of the terminal, tankers can manœuvre unaffected by weather conditions or by movement of other shipping—this last point is an important one in handling the concentrated volume of tanker tonnage anticipated when the new Fawley refinery comes into full operation.

NEW JETTY AND REFINERY AT THAMES HAVEN.

Now under construction in the Thames Estuary is a new type of oil jetty which, when completed in about a year's time, will form an important link in the oil supply chain to the new Shell Haven Refinery, Essex. This refinery adjoins the premises of the London and Thames Haven Oil Wharves who, under arrangement with the Shell Company are, at present, providing jetty facilities and much of the tank storage capacity required for incoming crude oil and outgoing refined products.

The Contract for building the jetty has gone to John Mowlem and Company, London; Marine and Engineering Consultants are Thomas C. Rallond and L. G. Mouchel and Partners. The jetty will be the largest in the Thames Estuary and will be able to accommodate tankers of up to 38,000 deadweight tons, 7,000 tons

Oil Port Developments—continued



Part Plan and Cross-Sections of the Fawley Jetty. Contractors, Christiani & Nielsen, Ltd.

more than the largest oil carrier now in service.

This £300,000 new addition to facilities at Thames Haven is unique in two ways—in its construction and in its fender equipment. The construction method involves a series of reinforced concrete cylinders sunk into the river bed, and is the first occasion on which pre-stressed concrete beams and fenders have been used in jetty construction, the latter, which are of a horizontal suspended type, based on a patent by Professor A. L. L. Baker, are the first of their kind to be fitted to any jetty.

The Shell Haven plant is one of two new refineries (the other is at Stanlow, Cheshire) being built by Shell in the United Kingdom which, when completed next year, will have a combined capacity of over 5 million tons per annum. The crude oil for both refineries will come mainly from the Middle East, and will be carried partly in the company's 28,000 ton tankers.

DETAILS OF THE JETTY.

The new Thames Haven Jetty is L-shaped, the approach being 414-ft. long and 23-ft. wide and the head 240-ft. long and 40-ft. wide.

Both the approach and the head are to be supported on 8-ft. diameter concrete cylinders, consisting of pre-cast reinforced hollow cylindrical sections, each 8-ft. long, the sections being spigot jointed together and the lower edge of the bottom section fitted with a steel cutting edge for penetrating the river bed. These are sunk into the river bed to a depth of about 34-ft. by weighting and grabbing (about 120 tons load on each cylinder) and then filled with concrete suitably reinforced. The shore end of the approach, where it rests on the sea wall, will be carried on bored piles.

There are five 77-ft. clear spans on the approach, each resting on a single cylinder with the exception of the river span, which rests on two cylinders at the river end. Each span consists of two pre-cast, pre-stressed concrete beams of I section. The beams are being made in three lengths on the shore, and after they have been placed in position on suitable supporting staging, the pre-stressing cables will be threaded through each section and the whole beam pre-stressed to form one continuous member.

The jetty head is to be supported on three dolphins, each consisting of six cylinders approximately 70-ft. long—three on the inshore side. Each pair of cylinders is connected with a cast-in-situ pre-stressed concrete box beam 9-ft. wide x 8-ft. 6-in. deep x 40-ft. long. Each dolphin is spanned by five pre-cast, pre-stressed concrete beams of I section. Unlike the approach beams, these are cast all in one length. The decking throughout the jetty consists of pre-cast concrete slabs. Those on the approach are 23-ft. long x 2-ft. wide x 5-in. thick and those on the head are 9-ft. long x 2-ft. wide x 4-in. thick.

" Bean " type bollards are being provided on the jetty head for mooring vessels—six on the front and five on the back—in addition to which mooring posts are being constructed upriver and downriver from the jetty to take the moorings of vessels. Ground moorings, consisting of screw piles, to which are attached bridle and pendant chains of about 3-in. cast steel secured to buoys, are provided to take the head and stern ropes of the vessels.

Samson posts with double derricks and electric winches are to be provided on the jetty head to deal with the suction hoses. Pipelines will be laid to headers on the jetty, and provision will also be made for water and steam pipes, telephone lines and lighting cables which will be supported on the handrails of the approach.

THE INSTALLATIONS FOR SCOTLAND.

Yet another new oil port has become necessary on Scotland's east coast, owing to the expansion of a refinery at Grangemouth. This expansion will necessitate the switching over of the existing tanker installations there to the handling of finished products only, and accordingly it was decided to make use of a jetty at Finnart, Loch Long, on the west coast, which had been built by the Admiralty during the last war. This jetty, expanded into an oil port, has been linked to the Grangemouth refinery by means of a 50-mile pipeline and will receive all future crude oil consignments destined for Grangemouth. The new port will be able to accommodate tankers of 28,000 tons or more d.w.—and the first consignment of crude oil was unloaded in February of this year.

These new oil installations are part-and-parcel of the overall programme to raise Britain's annual domestic refining capacity from its 1947 level of 2½ million metric tons to some 20 million metric tons by 1952-3. They are also essential complements to the oil industry's global plans for increased oil output, as are indeed the new overseas oil ports already reviewed, all such additional port facilities ensuring that the world's tanker fleet freighting the nation's crude oil supplies or purchases of finished petroleum products can load or discharge their cargoes with the maximum of efficiency and the minimum of time.

Model Studies of Apra Harbour

Carried out by California Institute of Technology in Collaboration with United States Navy Bureau of Yards and Docks

ROBERT T. KNAPP, Director.

(continued from page 371)

APPLICABLE WAVE THEORIES.

The major portion of the disturbances at Apra were due to wave action, and to interpret accurately the model investigation of such effects it will be convenient to define the established basic principles of wave action. Surface tension waves, that is ripples up to a length of 0.06-ft. in water of normal temperature will not affect the model results providing the shortest miniature wave length is considerably greater than this value. Our concern is with oscillating gravity waves, the deep water (short) waves and the shallow water (long) waves. It should be noted that this distinction is based on the ratio of wave length to water depth, and not on the absolute magnitudes: a wave length of 1,200-ft., crest to crest, in a water depth of 600-ft. is a deep water (short) wave but a wave length of 1,200-ft. in a water depth of 50-ft. is a shallow water (long) wave. The mathematical differences between the two types is the relationship of depth of water, wave length and velocity.

The classic expression for a gravity wave of small amplitude is,

$$c = \sqrt{g/K \tanh Kd} \qquad (1)$$

where c = wave velocity
$K = 2\pi/L$
d = water depth
g = gravity acceleration
L = wave length

when d/L is large that is for deep water waves, expression (1) reduces to

$$c = \sqrt{g/K} \qquad (2)$$

and for shallow water waves where d/L is small

$$c = \sqrt{gd} \qquad (3)$$

Now as the wave period $T = L/c$ we find that inserting this value in (2) the relationship is

$$L = 5.12\ T^2$$

from which we gather that short wave lengths imply short period waves and long wave lengths imply long period waves. The graph of Fig. 12 shows that when the water depth is over half the wave length the wave is a true deep water wave. It also shows that a deep water wave may approximately exist in a water depth of one quarter the wave length. Likewise it indicates that a shallow water wave may be considered to exist in a depth of one-tenth of the wave length. There is yet another difference in the

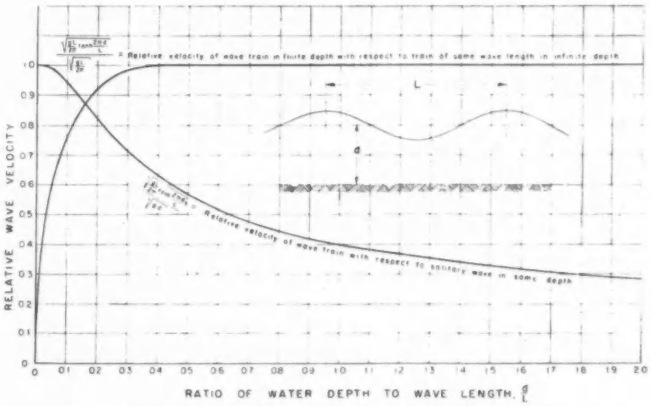

RELATIVE WAVE VELOCITY
RATIO OF WATER DEPTH TO WAVE LENGTH, d/L
Relative velocity of wave train with respect to solitary wave in some depth

Fig. 12. Relative velocities of deep and shallow water waves.

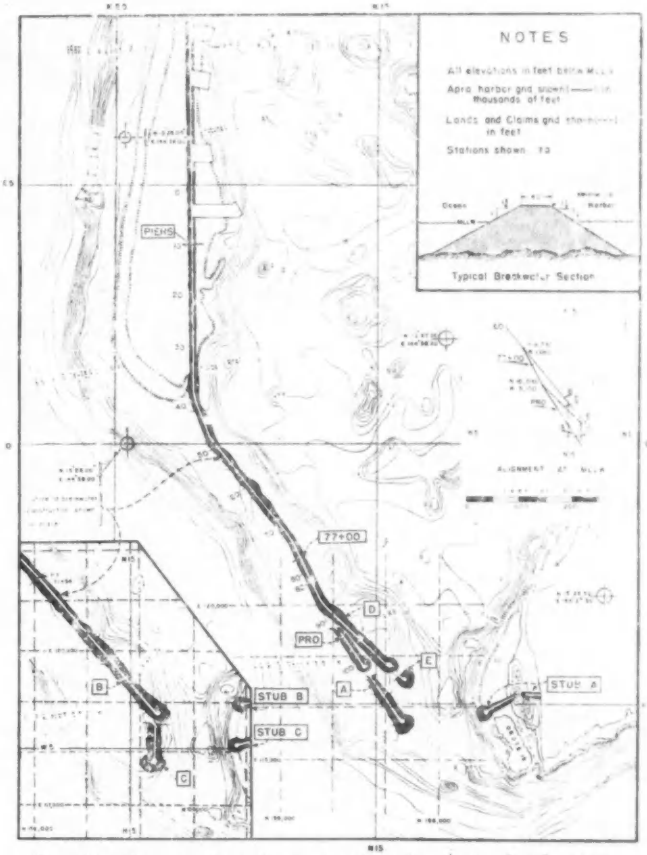


Fig. 13. Comparative alignments of various outer breakwaters.

orbital motion of the water particles. Thus the horizontal and vertical displacements of the water particles at a depth Z below the still water level are expressed as :

$$X_z = h/2\left(\frac{\cosh K\ (d+z)\ \cos K\ (x-ct)}{\sinh Kd}\right)$$

$$Y_z = h/2\left(\frac{\sinh K\ (d+z)\ \sin K\ (x-ct)}{\sinh Kd}\right)$$

where X_z = horizontal displacement from mean position at a depth z below still water level
Y_z = vertical displacement from mean position at a depth z below still water level
h = wave height
x = horizontal co-ordinate
t = time

then the full amplitude of oscillation of a water particle is

$$a = h\left(\frac{\cosh K\ (d+z)}{\sinh Kd}\right)$$

$$b = h\left(\frac{\sinh K\ (d+z)}{\sinh Kd}\right)$$

where a = horizontal amplitude
b = vertical amplitude

Model Studies of Apra Harbour—continued

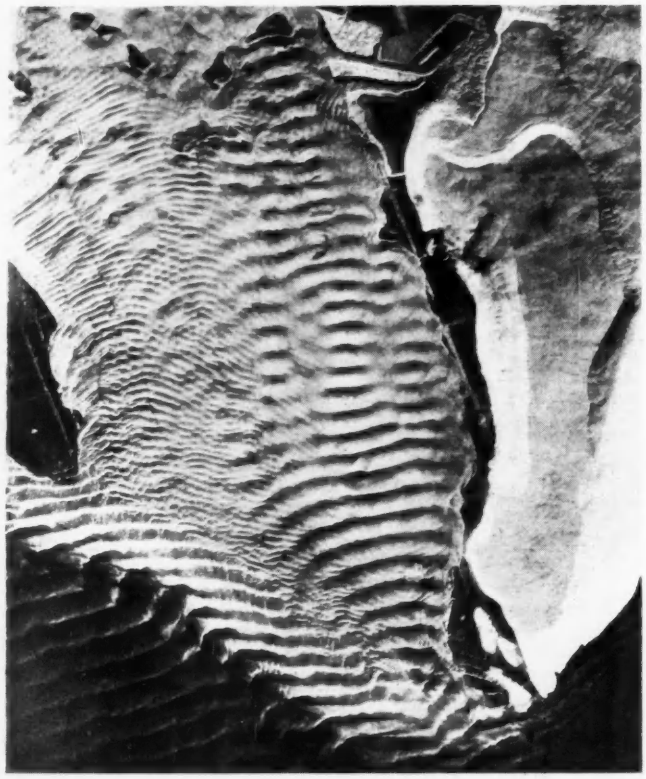


Fig. 14. Disturbances in unprotected harbour. Westerly waves 30-ft. high, 600-ft. long.

These expressions show that for deep water waves the orbits of the particles are circular and where d is large compared with L

$$a = b = he^{kz}$$

so that at a depth below the surface equal to half the wave length the particle motion is only 1/25th of the surface motion. This does not hold with shallow water waves for then the horizontal amplitude is greater than the vertical amplitude and we have

$$a = h/Kd$$

and

$$b = h\left(\frac{d+z}{d}\right)$$

Thus the horizontal amplitude is constant from the water surface to the bottom and the vertical amplitude decreases from b at the surface to zero at the bottom where $z = -d$. Therefore the orbits of the particles are elliptical from the surface degenerating into a straight line of backward and forward movement on the bottom.

A point of importance to note in connection with the orbital motion of gravity waves is the phenomenon of mass transport. Since the horizontal particle velocity decreases with distance below the surface, a water particle, which moves in the direction of wave travel when above its mean depth, and opposite to the wave travel when below its mean depth, does not return to its starting point at the end of one cycle, but is transported a small distance in the direction of the wave travel. This effect is more pronounced in the case of deep water waves than for shallow water waves since the variation of horizontal velocity with depth is greater for deep water waves.

Neglecting the effect of wind it will be appreciated that the damping of deep water waves is solely by friction between water particles, whereas the shallow water waves are also subject to damping by bottom friction. Since the velocity gradients are much higher in the case of bottom friction than for friction between adjacent water particles, waves are damped out more quickly in shallow water than in deep water under similar conditions.

SCALE DISTORTION IN MODELS.

The question of scale distortion in hydraulic models has aroused so many diversified criticisms that it is as well to define the relationships of model and prototype under the simulated and natural conditions which it was proposed to examine.

In the first place it was necessary to ensure that the scale of the model was such as to eliminate viscous effects such as would occur if the water depth were too small. Thus the flow had to be in the turbulent range where the Reynold's number was greater than 10,000, and the viscosity negligible, $R = vd/\nu$

where R = Reynold's number

v = velocity in feet per second

d = depth in feet

ν = kinematic viscosity in feet ^{2}/sec

Secondly, the phenomena associated with the water movement in the model had to be as closely as possible similar to that of nature. The model waves had to be true oscillating gravity waves having the pattern of the prototype but owing to the small magnitude of the vertical motion it is most difficult to measure. To facilitate the measurement of this dimension the model scale can be distorted by magnifying the vertical dimensions relative to the horizontal. However, there is a limit to this distortion, for if carried too far shallow water waves in the prototype may in the model then assume the character of deep water conditions. In the Apra harbour conditions both types of waves with their

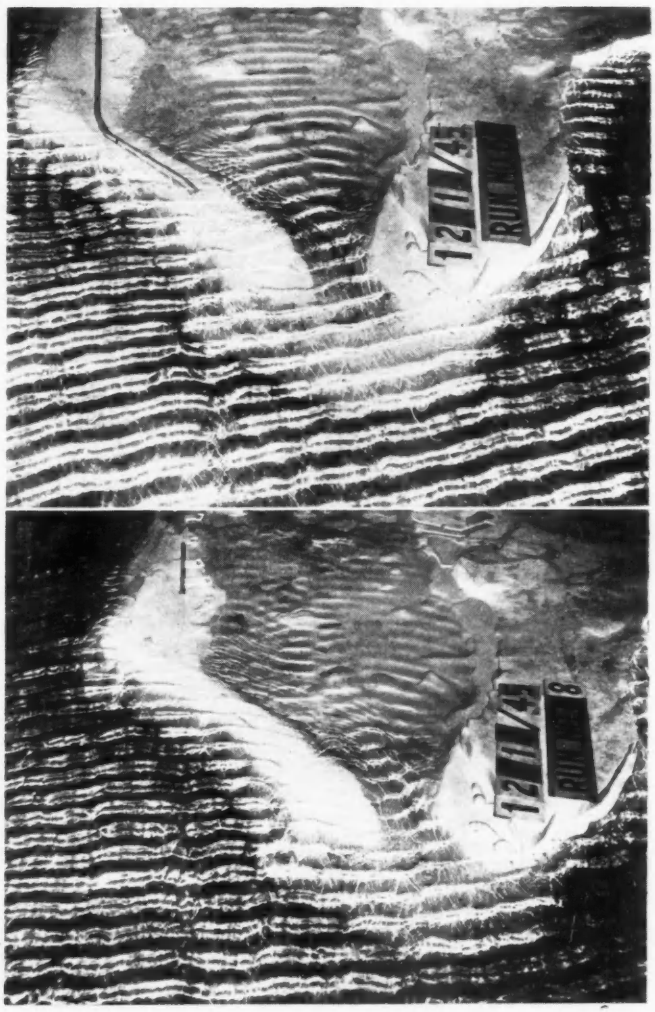


Fig. 15. Effectiveness of incomplete outer breakwaters. Westerly waves 30-ft. high, 600-ft. long. Top breakwater 77+00, below PIERS.

Model Studies of Apra Harbour—continued

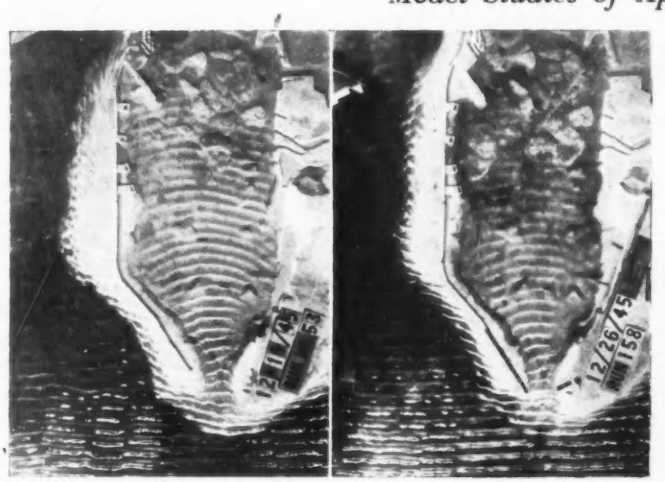


Fig. 16. Outer breakwaters PRO (left) and A (right). Westerly waves 30-ft. high, 600-ft. long.

graduations were present; within a short distance of the breakwater deep water waves of 600-ft. to 1,800-ft. in length existed, and inside the harbour, the same waves ranged from the transition type to shallow water waves.

For the breakwater studies matters were simplified as deep water conditions existed close up to the reef on which the wall was sited and therefore a distorted scale model of 2 : 1 had no disadvantage. However, for the harbour studies an undistorted model was considered necessary and, furthermore, to render easier the measurement of the vertical disturbances the linear scale was increased to 1/360.

Let. S_c = velocity scale

S_v = vertical linear scale

S_h = horizontal linear scale

S_t = time scale

then for shallow water waves $c = \sqrt{gd}$ and

$$S_c = \sqrt{S_v}$$

then

$$S_t = S_h / \sqrt{S_v}$$

but if the distortion factor $D.F. = S_v / S_h$
then

$$S_t = \sqrt{S_h / D.F.}$$

the corresponding expression for deep water waves where $c = \sqrt{g/K}$ and $S_c = \sqrt{S_h}$ is,

$$S_t = \frac{S_h}{\sqrt{S_h}} = \sqrt{S_h}$$

that is the time scale is equal to the square root of the horizontal linear scale and is independent of the distortion factor whereas with shallow water waves the time scale is equal to the square root of the quotient of the horizontal linear scale and the distortion factor. Thus it is obvious that in models subjected to shallow and deep water waves to obtain accuracy an undistorted model is necessary as then the time scale is equal for both cases.

THE OUTER BREAKWATERS.

The Bureau of Yards and Docks U.S.N., decided to construct the breakwater mound (Fig. 13) with a central core of stones of from 5 to 8,000 lbs. weight and to face the slopes with boulders weighing 4 to 30 tons weight. It was assumed that it would be impervious and therefore the model breakwaters were made also impervious, and were made in concrete. The first considerations of the model studies were confined to (a) determine the most suitable location of breakwater along Calalan Bank from the end of the existing wall as completed at the time, which was the station marked 77+00 (Fig. 13) thence south-west about 4,000-ft. to the tip of the bank. The alignment of the breakwater was restricted to a water depth of 45-ft. as closely as possible; (b) ocean waves—from the south-west, west or north-west. The severe storm waves (with a probability of occurrence five to ten times per year) of 10-ft. in height, 300-ft., 600-ft. and 1,200-ft. long. Typhoon waves (probable occurrence once every two years) 30-ft. high, 300-ft., 600-ft. and 1,200-ft. long; (c) ocean currents from the east and east-north-east at velocities of four and eight knots; (d) tides with a mean range of 1.6-ft. and spring range (diurnal) 2.3-ft.

Preliminary tests showed that the wave machines did not produce satisfactory waves of 30-ft. high and 300-ft. long. It was decided to discard them, and run the tests under wave heights of 10-ft. and 30-ft. and wave lengths of 600-ft., 1,200-ft., and 1,800-ft. from the directions given in (b), with and without the four and eight knot east and north-easterly currents.

The tidal range is so small that it was not considered in the tests, nor yet was the jobble effect on the harbour waters of the high winds occasionally experienced in the area. It may be of interest to note that in Dover harbour, which is much smaller than Apra and of much less internal fetch, jobble waves of 2-ft. amplitude are experienced.

The alignments of the breakwater and the various terminal arms tested are shown in Fig. 13, and the following table gives the various widths of entrances and the percentage relationships to the breakwater PRO.

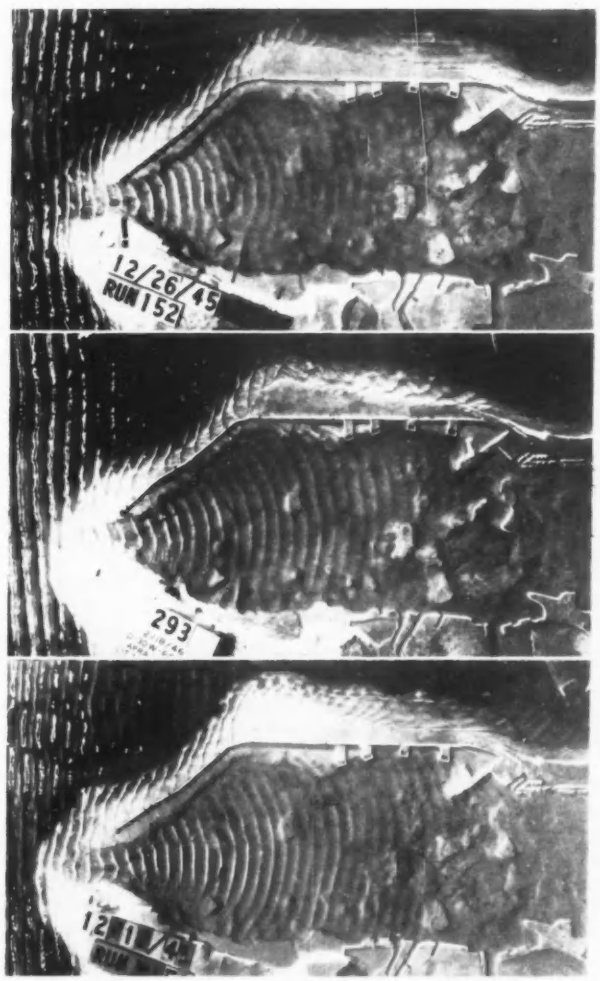


Fig. 17. Comparison of optimum breakwater, B (top) with most feasible D, and PRO (bottom). Westerly waves 30-ft. high, 600-ft. long.

Model Studies of Apra Harbour—continued

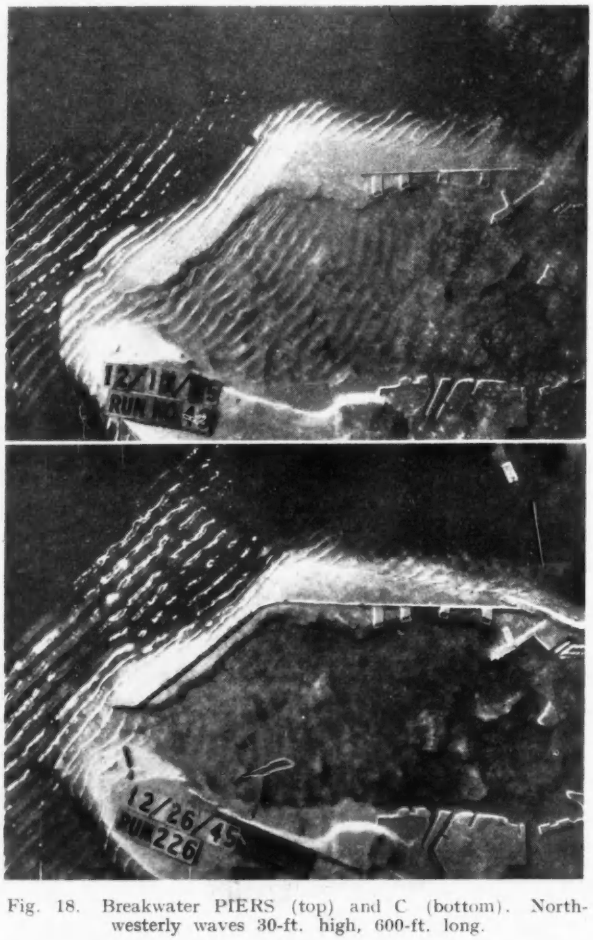


Fig. 18. Breakwater PIERS (top) and C (bottom). North-westerly waves 30-ft. high, 600-ft. long.

Designation of Projects	Entrance Width (feet)	Per cent. of Breakwater PRO
Piers	4570	220
77+00	3355	163
PRO	2080	100
A	1475	71
B	1510	73
C	1475	71
D	1595	77
E	1320	63

Of these, Piers was the state in which the construction was halted in December, 1941. It was an unprotected harbour. The top of the reef on which it was built is almost at sea level. The state 77+00 was a partially protected harbour and shows the position when the model studies were undertaken. From the large variation of the entrance widths in the table it is to be expected that there will also be a large variation of the amount of wave energy entering the harbour as :

$$E \propto w\ L\ h^2$$

where E = total energy per wave crest
w = width of wave crest
L = wave length
h = height of wave

Therefore with similar forms of entrance and similar conditions in the offing the relationship between internal disturbances as measured by the wave height due to different widths of entrance will be in proportion to the square root of the widths of entrances. Thus it can be assumed that comparison of disturbances arising from the entrances PRO and D will be in the proportion of $\sqrt{2080}$ and $\sqrt{1595}$ respectively, which would give an internal wave height for D approximately 88% of PRO.

WAVES WITHOUT OCEAN CURRENTS.

Westerly waves. The unprotected harbour, that is without breakwater protection west of the Luminao Reef, shown in the photograph (Fig. 14), presents some interesting characteristics. It is an undistorted model and thus is fairly representative of the natural conditions under westerly typhoon waves 30-ft. in height and 600-ft. long. The scale of the model is 1/360 vertical and horizontal. It is obvious from the photograph that the shallow Calalan bank gives considerable protection whereas the deep channel close to the Orote peninsula in the right-hand bottom corner allows the ingress of the ocean waves.

In the early stages, when the ocean wave mounts the Calalan bank the velocity is reduced slightly and the wave length is also decreased. There is only very slight change even over the shallowest part. There is, however, an increase in horizontal water particle velocity which at a depth Z below the surface can be expressed as :

$$V_z = 2h/T \left(\frac{\cosh K(d+z)}{\sinh Kd} \right)$$

Thus as a result of this the wave loses energy from the bottom and internal friction at a rapid rate, as the frictional forces are proportional to the square of the flow velocity. The wave form was therefore distorted and the near-sinusoidal waves were changed to waves of translation. There was a further transition in the deep water to the lee of the bank where a new series of short deep water waves was formed, the waves having a length of about one-quarter the original ocean waves and one-third of those which passed through the deep water channel. Now the wave energy per unit width of crest can be expressed $E \propto L\ h^2$, and, therefore it will be seen, these harbour waves contain only one-twelfth the energy of those which entered by the deep water channel; in other words, the reduction of energy caused by the bank is 75%, allowing for three wave crests occupying the place of one which would have entered if the bank were not there, and a wave height reduction of 50%. A point to note, too, is the increased wave disturbance about station 65 (Fig. 13) due to the

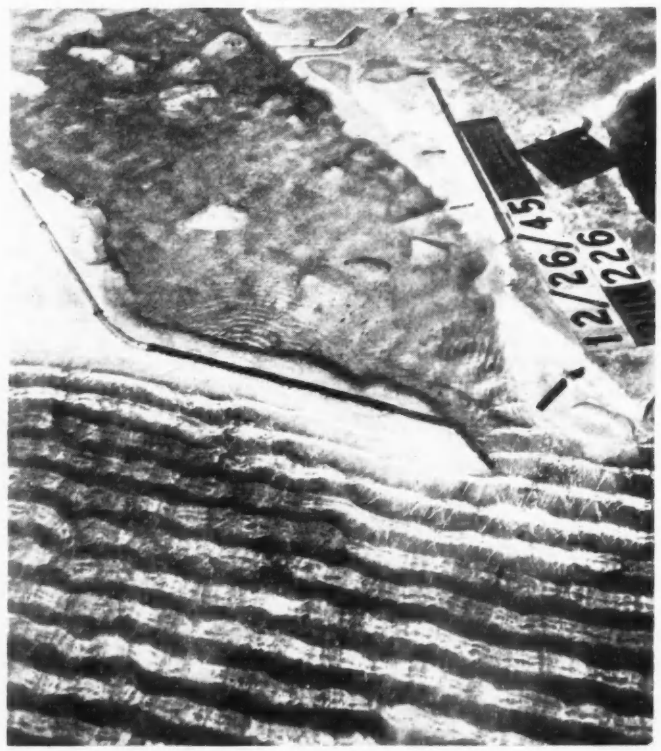


Fig. 19. Overtopping of breakwater C. North-westerly waves 30-ft. high, 600-ft. long.

Model Studies of Apra Harbour—continued

natural cavity in the bank shown by the contour lines. The photograph showed a concentration of waves about this point. In spite of the natural protection afforded by the Luminao Reef and the Calalan bank a short breakwater such as 77+00 reduced the

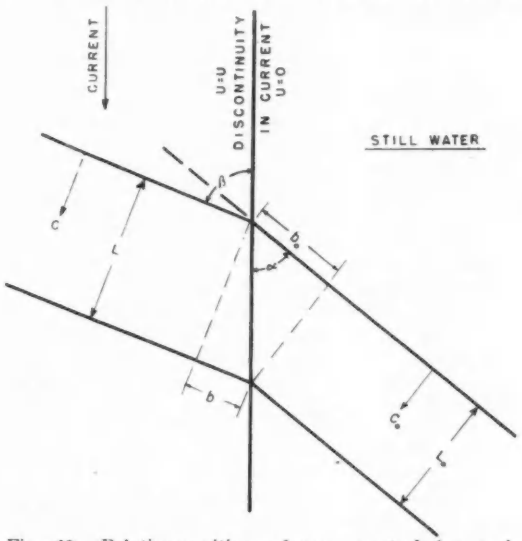


Fig. 20. Relative positions of wave crests before and after refraction by a current.

disturbance in the harbour; this can be noted in Fig. 15. Beyond this point the slight rate of decrease of disturbance with further extension of the breakwater to the west was not so noticeable. The runs with PRO and A (Fig. 16) showed similar patterns though slightly less in magnitude than 77+00, and although the theoretical ratio of disturbances inside the harbour of these two cases are 10 to 8.4 it was not discernible in the photographs. The stub breakwater for case A showed no advantage. Overtopping of PRO and A with top deck level at +18-ft. occurred in several places and as before was most severe at station 65. Both breakwaters were aligned in the centre of the Calalan bank.

The breakwaters B and C were aligned along the harbour side of the bank to obtain the maximum protection from it. These showed in the respective runs little change from the above cases; the overtopping was slightly less excepting near station 65 where it was severe. The spur arm of breakwater C did not show any noticeable effect inside the harbour or the harbour entrance but it undoubtedly formed an undesirable elbow for wave concentration and overtopping. These test runs indicated that breakwater B was the more desirable of the four so far examined, however, it had the great practical disadvantage of an alignment through deep water and was therefore a costly project.

In conference with U.S.N. Bureau of Yards and Docks, two further alternative alignments were suggested; they were the breakwaters D and E, the latter being about 400-ft. longer than D, with the head in deep water. The test runs showed little difference between the two and thus confirmed that there was little or no advantage in extending D to E. Fig. 17 compares the three cases, B, D, and PRO, and unmistakably shows exceedingly slight differences only, favouring B, with D a close second.

NORTH-WESTERLY WAVES.

It is interesting to compare the photograph of Figs. 14 and 18, bearing in mind that the former is an undistorted scale model whilst the latter and all others so far used have a distortion factor of 2. Obviously the disturbances within the harbour were considerably reduced by a breakwater and there was considerable overtopping by the seas coming from the north-west, particularly near station 65 (Fig. 19.) The semi-circular ripple-like disturbance to the lee of the breakwater showed the effect of the overtopping. The spur to the breakwater terminus C was effective against north-westerly waves in reducing the disturbance about the harbour entrance, but the elbow still had an objectionable effect. It was also noted that the wave fronts inside the harbour from the entrances had very similar alignments, due to the influence of the 160-ft.—300-ft. deep water channel. All the breakwaters showed the same effect in similar degree and therefore it may be safely assumed that the channel controls the direction of the advancing crests pattern, along the west-east axis of the harbour. The order of effectiveness of the breakwaters against north-westerly waves was C, B, E, D, A and PRO in decreasing order, yet from economic and hydrodynamic considerations D was rated as the most feasible.

SOUTH-WESTERLY WAVES.

The prominences of the Orote peninsula provide excellent screening from the south-westerly seas which only graze the Calalan bank. Again the directional influence of the deep water entrance channel was observed to swing the entering wave fronts along the west-east axis of the harbour. The breakwater PRO located farthest offshore and the breakwater B located closest inshore showed almost similar degrees of disturbance under the south-west seas. The other breakwaters differed only slightly, except C, where the spur head showed the objectionable feature of reflecting the waves into the harbour entrance channel. Breakwater E gave the best results, and D was next best, but considering the economic factors, as before, D was pronounced to show the more favourable qualities.

WAVES WITH CURRENTS.

One of the great advantages of hydraulic model study is the ease in which each separate factor of importance may be investigated singly, and the individual tendencies on the harbour regime noted, so that when the complex system is fully operating it becomes possible to diagnose with some certitude the causal phenomena of the salient features. In few cases is this more useful than in the investigation of the influence of currents and further in the tracing of the sources of local alongshore currents. The tests so far described were run in quiet water without currents. The next step was to make model runs under currents only of four to eight knots in quiet water from the east and north-east, as shown by the arrows of Fig. 5. These tests showed that the ocean currents induced no appreciable movement or effect on the harbour waters.

The succeeding runs were then carried out with waves and currents simultaneously. This combination introduced the phenomena of refraction of the waves at the boundaries of the differing water movements. For example, consider the case of the refrac-

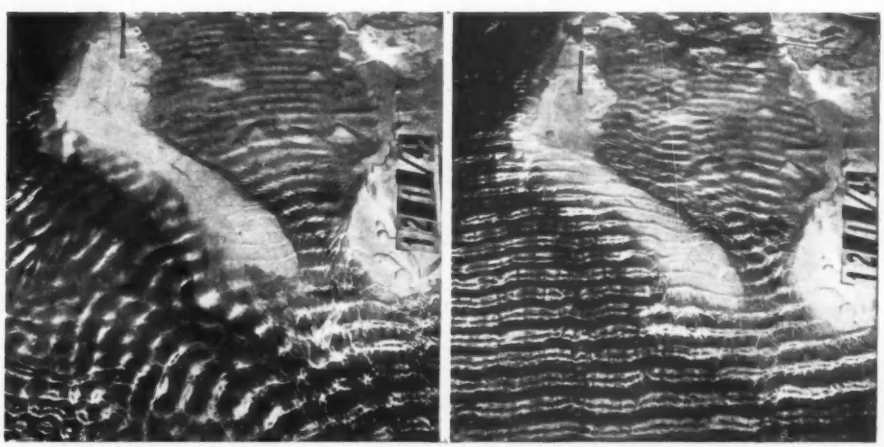


Fig. 21. Breakwater PIERS—8 knot ENE current (left) and no current (right). Westerly waves 30-ft. high, 600-ft. long.

Model Studies of Apra Harbour—continued

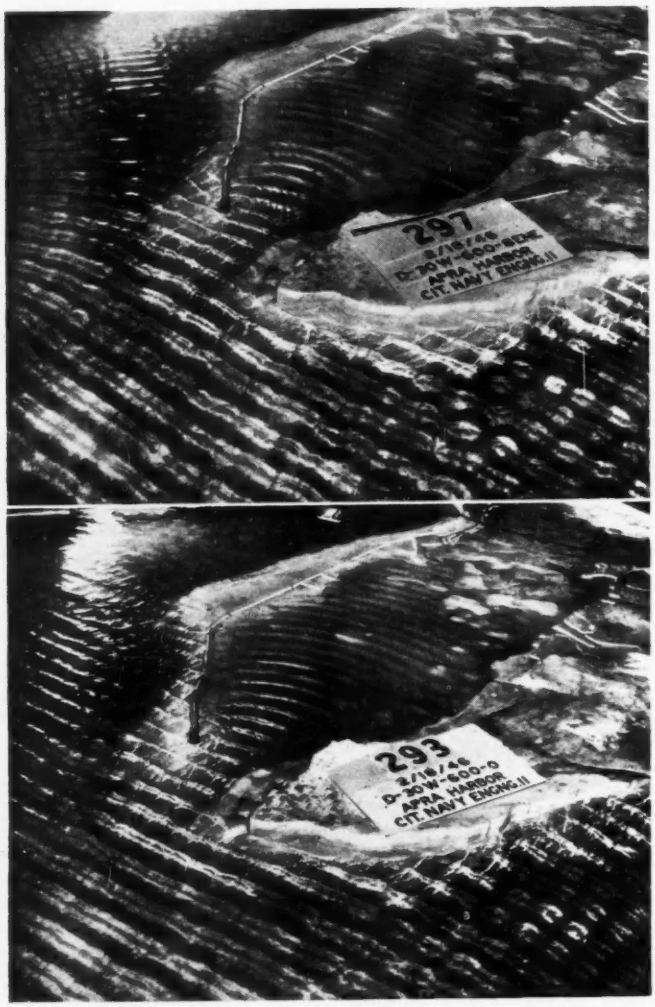


Fig. 22. Breakwater D—8 knot ENE current (top) and no current (below).

tion of surface waves at the boundary of an ocean current and still water (Fig. 20). When the waves running originally through still water encounter the current the consequent change of velocity will cause refraction and there will result a change of direction, wave length and wave steepness. The wave length L_0 and the wave velocity C_0 of the original wave will be changed to L and C respectively on the current side of the boundary, and the original direction of travel of the still water waves front will be swung through an angle $(\beta - \alpha)$ with the original front. Further, it will be noted that a length b_0 of the original crest will be compressed to a length b in the crest of the current wave.

Then $L/L_0 = 1/(1 - m \sin \alpha)^2$

where $m = u/C_0$ = current velocity/original wave velocity

and $b/b_0 = \cos \alpha / \cos \beta$

where $\sin \beta = \sin \alpha / (1 - m \sin \alpha)^2$

The change in wave steepness is given by

$$\frac{H/L}{H_0/L_0} = \sqrt{\frac{\cos \alpha}{\cos \beta}} \left(\frac{1 - m \sin \alpha}{1 + m \sin \alpha} \right)^6$$

The most common and visible occurrence of wave refraction occurs when a shallow water wave encounters a shelving foreshore at an oblique angle, the inshore end of the wave front moving slower than the offshore crest, the front tends to swing in parallel with the beach line.

The tests showed that waves from the westerly quadrant on encountering the strong easterly or north-easterly currents were so bent as to increase the length along the crests and to suffer shortening of the wave length. It should be appreciated that currents of four and eight knots are unusually high and therefore exaggerate the distortion of the waves. The decrease in wave length tended to bring the waves to an unstable condition and therefore rob them of their basic characteristics. An important feature that showed itself in the model, even when there were no waves running but only the E and ENE currents, was the presence of a large counter clockwise eddy 3,000-ft. to 4,000-ft. diameter. It lay offshore from the centre of the Calalan Bank. The same phenomenon occurred when waves and currents were passed through the model. This confirmed certain reports from navigators and information from the Bureau of Yards and Docks that a strong eddy was frequently experienced offshore—sometimes sufficiently strong to swing a vessel 40° off her course. Generally, it was found in all tests that the disturbances in the harbour were less with combined runs of waves and currents than with waves alone.

This powerful influence of currents on wave form is well illustrated by the photograph (Fig. 21) of the partially protected harbour PIERS, which shows quite clearly the severe eddies off the Calalan Bank. The distorted waves cause less disturbance than the wave fronts without current. It will also be noted that the pattern of waves in the deep water channel with and without current are similar, but the disturbances in the harbour in the former case are less intense than with waves alone. There was very little difference in the behaviour of all the breakwater cases; the current tended to reduce the height of waves along the ocean face of breakwaters yet overtopping of +18-ft. breakwater height still occurred.

The spur at the entrance head of breakwater C had the effect of reducing the eddy current slightly about the entrance. The currents appeared to have greater effect upon the shorter length waves. The breakwater D was tested in greater detail than the others and Fig. 22 shows the two conditions with and without current under westerly waves.

R.R.M.

(To be continued)

Book Review

"Gas Discharge Lamps" by Funke and Oranje (Members of the Research Laboratories of the Philips Industry, Holland). Published in the United Kingdom by the Cleverhulme Press, 42a, South Audley Street, London, 270 pp, 171 figs., 39 photographs, price 30s.

This volume is a compilation of work previously published in the form of papers and articles in the Philips Research Reports together with some unpublished notes. It presents a survey of the existing types of discharge lamps as marketed by N. V. Philips Gloeilampenfabricken, Eindhoven, Holland, and discusses their relative possibilities, characteristics and principles and states that the scope of the book is to give the reader a practical manual couched in simple terms.

From these remarks the reader will gather that, being sponsored by a manufacturer of lamps, it is an authoritative work which can be applied equally to the products of other firms in the lamp industry.

The book is divided into two parts. The first covers general principles together with the relation between gas discharge lamps and their auxiliary equipment. Part two deals with sodium lamps, and the various types of discharge lamps including low-pressure tubular lamps. The last chapter deals with stroboscope lamps and flash tubes.

Attention has been given to the layout of the book, which for easy reference is paragraphed and indexed so that answers required for awkward questions come quickly to hand.

It can safely be recommended as a most useful handbook to engineers and others concerned with the practical aspects of lighting by discharge lamps.

Factors Affecting Cargo Handling

Efficient Methods at the Port of Sydney

By G. H. FAULKS
(President Maritime Services Board, N.S.W.).

When the number of ships arriving in a port rises well above average, and this happens periodically, the extra cargoes on the wharves may lead, deservedly or otherwise, to charges of congestion. Variations in the tempo of port activity are nothing new. They are inescapable. Shipping, by its very nature, cannot be regulated into a steady flow—it is subject to fluctuation, more particularly so wherever seasonal factors operate.

In common with most world ports, Sydney experiences these fluctuations, and has always done so. The difference to-day, however, is that they are liable to aggravation by factors which were non-existent in the past. It is now necessary to redouble every effort to minimise their effects, and in this respect the Board, as the Port Authority of Sydney, claims credit for what has been achieved within the sphere of operations coming under its direct control.

The working of a port may be likened to the running of an engine. Smoothness of operation results only if all the component parts function in harmony. Thus, as there are just so many factors in the set-up of waterfront activity, there are exactly so many which can affect operations. The main factors number at least a dozen. Shipowners, ship agents, wharf managers and supervisors, stevedores, port labour, carriers, consignees, shippers, bonds and stores, the Customs Department, Customs House agents, the Department of Railways—all these have specific functions to fulfil in co-operation with the Port Authority to ensure the smooth working of the port. If any one of them falls short of the standard, the performance of the remainder is adversely affected.

It is customary to compare the present with the past and, on 1939 standards, there is no doubt whatsoever that performances have slipped badly. Probably as well as any other Authority, the Board is equipped to measure the extent of the deterioration that has occurred within its sphere of operations. From its own records it knows that nine wharves are now required to work the cargoes formerly handled by eight (and that proportion would have been much worse had not the Board evolved an improved system of control and use of the available wharfage). It knows the extent to which the turn-round of vessels has been protracted. It knows that the port labour force has lost its flexibility and that its output is less per man. It has a measure of the effects of the 40-hour week, of the standards of cargo handling, and of all the other matters of which it is expected to be aware. At the same time, its approach to all these problems is realistic—it appreciates that a fast moving period of change has occurred and that much of the change may be permanent.

The 40-hour week, the post-war inflation, the shortage of manpower and materials—these factors have affected its plans just as much as they have affected those of any other organisation.

The Board believes, however, that difficulties arise to be overcome and that stability will eventuate with time. In the interim its policy is aimed at maintaining its own efficiency to the fullest extent and at inducing others whose interests are on parallel lines to do likewise. Such a policy involves the use of example, education, and, in a minor degree, compulsion through the medium of penalty charges in cases where private interest runs counter to the interest of the port as a whole.

Following is a brief reference to the present circumstances and situations, and the ways in which they are, or should be, handled. The examples are intended to describe matters just as they are, and no inference should be drawn that any particular party is to be blamed or criticised.

In the provision and allocation of berths, advance information on arrivals is essential. Shipowners now notify the harbour master of projected movements of vessels and cargoes in accord with their own advices. In the year ended 30th June last, this co-operation enabled the harbour master to place 94 per cent. of vessels at berths immediately upon their arrival. With the co-operation of the shipowner's committee responsible for allocating labour, it has been possible to clear berths in many cases more rapidly than would otherwise have been the case. Incidentally, the clearance of ships from wharves is to-day the Board's greatest difficulty—the clearance of cargoes is a minor problem in comparison—and considering that the past year was marked by a seven-weeks coal strike, two other industrial disputes which were very serious in their effects, a return of oversea shipping to near the 1939 volume, and an unprecedented amount of wet weather, the degree to which vessels have been promptly accommodated may be considered something of an achievement.

It is more of an achievement when it is considered that ship times at berths in relation to their cargoes are now roughly double what they were pre-war. The Board can do little about this, since it is largely due to the inflexibility of the labour force, over which it has no control.

Pre-war, busier-than-usual periods were met by various adjustments which resulted in clearing ship cargoes with reasonable celerity. Now they are characterised by serious delays while vessels wait for labour to become available. Labour shortages are persistent month after month and it only requires a dispute, or bad weather, to operate for even a short period to seriously aggravate the position. When a practical solution to this problem is discovered, many other difficulties will dissolve automatically. Flexibility of the labour force is fundamental to the whole problem.

In the actual handling of cargo, the Board would like to see the general standard of stevedoring practice improved in line with the best examples in the port. Between the worst and the best there is a bigger gap to be bridged than seems justified by the expected differences in the abilities of men. The accepted principles which make for the conservation of floor space in sheds, the preservation of adequate lanes between stacks and the disposition big lines and certain types of cargo in the most convenient locations—these and similar examples are matters of technique which should not be transgressed. Stevedores, their foremen and workers, tally, stacking and delivery clerks, all carry responsibility which, faithfully discharged, lightens the problems of other people whose job is the movement of ships and goods.

Particularly do they help the carriers, whose difficulties are sufficiently heavy without being unnecessarily added to by inability to find, or gain easy access to, the goods they require. It is recognised that carriers generally are doing an excellent job, and they, least of all, can afford wasted time. The 40-hour week has limited receipt of goods into stores to 4 p.m. daily, and this alone means that their fleet units lose at least one trip-load each day, which forces them to operate additional units to maintain their turnover. Anything that minimises their delays at wharf, rail or store must help the general situation.

Essentially, delay anywhere along the line is Public Enemy No. 1. It is cumulative in its effects. Delay to a ship in berthing, delay to documents in the Customs House or the Customs agents' offices, delays from any cause mean delays in delivery of goods and extra expense, which ultimately must be borne by the community in the extra cost of the goods concerned.

Delays to documents at the Customs House have been minimised by the co-operation of the department which ensures the checking of invoices before arrival of the goods in port. Delays in handling documents by Customs House agents have occurred on occasions as a result mainly of inability to secure sufficient trained staff, but in the majority of cases their work is characterised by a commendable degree of promptitude.

Delays by merchants in removing their goods from wharves are oft-times in a different category. Faced with a pressing shortage of storage accommodation in and around the city, the practice of using the wharves as temporary stores grew to alarming proportions and the Board was reluctantly forced to use compulsion—through the medium of penalty wharf storage charges—in order to enforce prompt clearances. These charges were definitely not imposed for revenue purposes, and the Board would be quite happy to see a negligible collection from them. (Incidentally, their efficiency has been well demonstrated by a heavy decrease in the storage revenue since the rates were lifted to penalty levels.)

Factors affecting Cargo Handling—continued

Shippers also frequently fail to co-operate with shipping companies in the matter of sending goods down to the ship in accordance with their arranged time schedule. When the ship fixes a programme to receive so many certain loads at pre-arranged times, it aims to suit shippers' convenience as well as its own, and if merchants fail to keep to schedule, delays and congestion are inevitable.

The foregoing examples serve to show the inter-relation of all the parties who contribute to the activity of the port, and the desirability of their close co-operation in their own and the collective interest.

As previously indicated, the Board is doing all that lies in its power to give efficient service. It has appointed traffic officers especially to assist merchants, stevedores and carriers. It is pressing on with construction work as fast as circumstances will permit, using private contractors in addition to its own employees. It has sought and received the co-operation of other interests in many ways, and it is appreciative of the general spirit it has discovered, which is expressed in a willingness to constructively grapple with present problems.

The Board feels that the right approach to any difficult situation is not to be found in recrimination or blame placing, but in a frank recognition of facts and a constructive co-operative attitude towards rectifying them. It feels that in the spread of this idea lies the best hope for eventually straightening out problems which in their nature should be temporary rather than permanent.

Result of good stacking. Note ease of access to cargo.

An illustration of good stacking. The two-ton travelling bridge crane is capable of stacking at any point in the shed. Note the absence of centre supports.

Cargo top-stacked with fork-lift. Note conservation of floor space, and fork-lift fitted with detachable jib. A feature of fork-lift equipment is its manœuvrability. Ample laneways have been left which make for prompt deliveries and quicker clearance of sheds.

Health Control of Sea Traffic

Agreement on Uniform System

By agreement amongst the five Brussels Treaty Powers—Belgium, France, Luxembourg, the Netherlands and the United Kingdom—a unified system of Health Control over Sea Traffic entered into operation on 1st March, 1951, as a result of which, for practical purposes, the five countries will constitute a single territory as in the case of air traffic.

Allowance being made for any necessary adminstrative adaptation by each of the five Countries, the Maritime Declaration of Health will be waived in the case of all ships, whatever their flag, plying between the ports of Western Union countries (including the Atlantic and Mediterranean ports of France) on condition, however, that these ships do not call at the port of any other country (including Gibraltar) on the way.

In normal health circumstances there will be no necessity for such ships to wireless a request for free pratique.

The following measures will, therefore, apply to all such vessels:

(a) The vessel will show the appropriate international flags or signal lights to indicate the state of health on board on approaching the port.

(b) If no case or suspected case of infectious disease is present or has occurred on board during the voyage, the vessel may proceed immediately to her berth — subject to any requirements of the Harbour Authorities or the Customs.

(c) Immediately free pratique is granted (frequently this is done before or as soon as the vessel ties up), the normal boarding by agents and other authorised persons, the disembarkation of passengers and the unloading of cargo may then, so far as the Port Health Authority is concerned, proceed.

(d) During the stay of the vessel in the port, the Port Health Authority may board and inspect the vessel at any time and if infectious disease is discovered take any necessary action as permitted under the regulations of the country in which the port is situated. The Authority may also examine, and if necessary detain or remove to hospital, any person on board who is suffering or is suspected to be suffering from an infectious disease, or who is verminous, and may impose such other preventive measures (e.g. disinfection, surveillance, etc.) as may be considered necessary.

(e) The master shall provide any information on the request of the Port Health Authority and notify the occurrence of any sickness suspected to be of an infectious nature.

(f) The procedure for the issue of international certificates of deratisation or exemption from deratisation at designated (approved) ports will remain as at present.

Under abnormal or exceptional circumstances (e.g. in the event of a port in a Western Union country being declared infected with one of the " Convention " diseases or a case of serious infectious disease being present on a vessel), the Port Health Authority will act in accordance with the port health practice of the port of arrival.

Correspondence

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

TIDAL SAND RIPPLES

With reference to the article on " Tidal Sand Ripples " contributed by Professor Jack Allen of Aberdeen University in your March issue, it may be of interest to your readers to know that very large sand ripples are known to exist in the Gulf of Corryvrechan situated at the north end of Jura, between Jura and Scarba.

On two occasions I sailed through this gulf on a survey expedition when the " Echometers " fitted to the fishing boats which we used registered a regular saw-tooth bottom from one end of the gulf to the other. From memory I would say that the ripples were no less than 60-ft. high and even more regular than the ones located at Dundee. The depth of water in this gulf is over 500 feet and the turbulence caused by the rush of water through this gulf forms the " Great Race."

Admiralty Chart No. 2515 gives some indication of the depths and general conditions.

Shots for the film " I know where I am going " were taken in the Gulf of Corryvrechan which is famed for whirlpools etc.

It may be that the Corryvrechan would be a good place to check any law established to govern the height and wave length of " sand ripples " in view of the great depth of water, the speed of the tide and the great height of the ripples.

Yours faithfully,

A. M. ROBERTSON.

County Engineer's Office,
Lochgilphead, Argyll.
9th April, 1951.

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

TIDAL SAND RIPPLES

Re Professor Allen's letter on the above subject. During summer 1950 the National Research Council of Canada authorised observations on bed-waves in the Fraser River estuary (tidal) in connection with a Model. Daily observations were made for about a month, over four cross-sections and one longitudinal line. The work was carried out by the Dominion Dept. of Public Works, using their standard sonic sounding gear. Sediment samples were taken concurrently. The time was chosen to contain the peak of a high flood—over 400,000 cusecs. The object was to obtain data for proving the model. The existence of bed waves is well known, but their detailed study has received surprisingly little attention considering the ease with which the waves are recorded by standard modern equipment; a model that cannot show the broad outlines of actual behaviour can hardly be considered very satisfactory. The bed-sand size is about 0.3 mm. The analysis of the results has not been released yet, but looks both interesting and instructive.

Yours sincerely,

T. BLENCH.

University of Alberta.
Edmonton, Canada.
3rd April, 1951.

Consulting Engineer and
Assoc. Professor of Civil Eng

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

THE SUPPLEMENTARY RESERVE

You will no doubt have seen mentions in recent months, both in Parliament and in the Press, of the Supplementary Reserve for the Army.

This Reserve has recently been reconstituted and we have written to a large number of ex-servicemen explaining the purpose of the Reserve and asking them to consider joining in the Arms or Corps to which they formerly belonged. We have found some difficulty in getting information out to employers in industry, and think that many employers may not be sympathetic to their employees who wish to join this Reserve, because they do not fully understand its object.

The object of the Supplementary Reserve is, broadly, to provide the technical and administrative units needed to form the essential backing to the fighting formations of the Regular Army and the Territorial Army immedately on mobilization. The Supplementary Reserve is not part of the Territorial Army but an essential complement to it. In structure its units are similar to those of the Territorial Army, in that they consist of basic elements of volunteers to provide the senior officers and N.C.Os., completed ultimately with National Service men during their part-time service. But the units are raised essentially on a trade or " skill " basis and not territorially.

Because members of the Supplementary Reserve will normally be technicians whose military employment will be almost identical with their civilian occupations, and also because of the difference in organisation as compared with the Territorial Army, there is no liability for evening drills or week-end training. The normal training liability is an annual 15 day camp, and in certain cases military training in peace time is not needed at all. A pamphlet which gives details of the liabilities, terms of service, pay and the like, will gladly be sent to anyone who may be interested.

You will wish to know the position about reserved occupations. The principles and procedure for these will be identical with those devised for the Territorial Army, which have recently been accepted on behalf of both sides of Industry by the Minister of Labour's National Joint Advisory Council. We only enlist volunteers into the Supplementary Reserve provided that they have been cleared in this respect by the Ministry of Labour.

I hope that this letter will give you a clear picture of the object and importance of the Supplementary Reserve and of the essential part which the volunteer element fulfils in this organisation.

Yours truly,

JOHN CROCKER.
General,
Adjutant General to the Forces.

War Office,
London, S.W.1.
20th March, 1951.

Defective Concrete in Marine Works

A report published recently by the Portuguese Ministry of Public Works, and reviewed in the March 1951 issue of " Concrete & Constructional Engineering," describes the results of an investigation of the condition of cement mortars and concretes at the principal ports in Portugal.

In the north of Portugal, where granite aggregate is used, there is much defective concrete, while elsewhere concrete about fifty years old is in an almost perfect condition. The granite is generally a coarse-grain material composed of two types of mica. Defective concrete is cracked and is easily disintegrated. The following conclusions are drawn from analyses and tests of the materials used in the works and of samples taken from the structures.

The hypothesis that the defects are primarily due to the action of sea-water on the cement is rejected, although the presence of sea-water may accelerate disintegration due initially to other causes. Generally, the cements used in defective works built in the past twenty years are the same as those used in works showing no deterioration and built in the same period. The chemical composition and physical properties of the various cements are very similar and fluctuate little. It cannot be said that the concretes are deficient in cement. The quantity of cement in 1 cu. yd. of concrete showing the worst defects is from 500 lb. to 760 lb.

As the defective concrete is almost entirely confined to the area where granite occurs, it is thought that the primary cause is the interaction of the cement and aggregates. Chemical analysis of a white paste exuded from some concrete blocks weighing 90 tons suggests that reaction between the aggregate and the alkalis in the cement was occurring because the silica-content of the paste was low. The view that cement-aggregate reaction is the primary cause is strengthened by the condition of the fractures of some broken blocks, the surfaces of which were in good condition. The good condition of some concrete in the granite region is attributed to the great care taken to obtain compact concrete, thereby confirming the common view that concrete in sea-water must be well made and

(continued at foot of next page)

Heavy Lift Crane for Port of Sydney

Unusual Method of Cylinder Sinking Employed

Last February the Australian Naval authorities finished building at Garden Island Navy Yard, Sydney, a crane which is one of the largest in the world, being a replica of the one erected at Singapore dock before the war, and subsequently destroyed by Allied forces to prevent it falling into Japanese hands.

The new crane which has been constructed as part of the Australian defence expansion programme, is 203-ft. high from wharf level, including the height of a 6-ton travelling crane which runs on top of the main arm. The length of the main crane is 273-ft., with a working radius of 178-ft. It can be operated by one man, and will lift over 250 tons (the Singapore crane lifted 312 tons during tests).

Although the plans and drawings were prepared by Sir William Arrol & Co. Ltd., engineers, of Glasgow, Scotland, on behalf of Sir Alexander Gibb & Partners, the crane was constructed by Australian workmanship, as all the steel was produced and all the constructional work done by Australian labour in about 20 months. Sydney Steel Co. Pty. Ltd., manufactured the structural steel, and the steel work was assembled in the company's yards and then dismantled and re-assembled on Garden Island in permanent form. The motors, motor controllers, control panel winding winches and other appliances, however, are of British manufacture.

One of the major constructional problems was to sink the foundations, which, to be adequate had to be 130 feet deep, 90/100 feet being below the sea bed. This task was carried out by the Maritime Services Board of New South Wales, who control the Port of Sydney, and all other ports in the State, for the State Government.

Some years ago, when coffer dams for the fitting-out wharf at Captain Cook Dock were being sunk, it was found that the clay at the bottom of the coffer dams was so stiff that it was impossible to excavate with an ordinary grab. The only satisfactory means of removing it was to send down a diver to break up the material with high pressure water jets and subsequently eject it with an air lift. Encouraged by the success of this method of excavation on a limited scale, the engineers decided that some similar system should be adopted in the sinking of the crane foundations.

A cylinder, 20-ft. in diameter at the cutting edge was sunk through 50 feet of clay to rock, in preparation for the foundations, and this made the total depth to completion of the excavation nearly 100-ft. below water level. A contract was let for the supply of 4-in. diameter 5-stage centrifugal pumps each capable of delivering 800 gallons of water per minute, against a pressure of 150 lbs. per sq. inch. Two of these pumps were used and gave very satisfactory service. With water working at such high pressure, special pipes were necessary and the fitting throughout, had to be designed specially for the pressures involved. Seven jets were employed; three of them were connected to a fixed central arm and had orifices of one inch diameter, and the other four with orifices of $\frac{5}{8}$ inch diameter, to each of the four wing extending arms. The whole equipment was operated from the surface, and by gradually cutting down the centre core inside the cutting edge, the weight of the cylinder which was continually being increased, was able to force the cutting edge into the clay and gradually squeeze the material into the centre of the core that had been excavated. This process was repeated, enabling the cylinders to sink gradually through the very stiff clay until rock was reached. As before, the material which had been excavated by the water jets was removed by an air lift, which discharged an average of $1\frac{1}{2}$ cubic yards of spoil an hour. The rate of sinking was controlled, and no difficulty was experienced in keeping the cylinders vertical in poistion.

View of crane which was recently completed at Garden Island Navy Yard, Sydney, Australia.

This is thought to be the first time equipment of this type has been operated in this way; the idea was conceived and developed by technical officers of the drawing office of the Maritime Services Board's engineering branch. They are very satisfied with the results of their design, and its performance in the carrying out of this rather difficult operation.

Captain Cook Dock area, which the crane is to service, was opened in 1945 at a cost of £A9,000,000. It can accommodate the largest ship afloat, and is one of the most vital defence units available to the British Commonwealth in the Pacific. The new crane will add greatly to its efficiency and effectiveness, and its main use will be to lift complete gun turrets on and off the decks of warships.

Defective Concrete in Marine Works

(continued from previous page)

dense. Although the primary cause of the defects may be cement-aggregate reaction, it is apparent that the defects are strongly influenced by the sea-water.

Compression tests confirm the observations, since the strength of the cubes of defective concrete decreases in course of time, whereas the strengths of the corresponding sound concretes increase. This shows that knowledge of the early strength of concrete is not a proof that it will continue to have the same strength. The following are the compressive strengths (in lb. per square inch) of the concrete of some works that have become defective. The strength of a concrete with 500 lb. of cement per cubic yard increases from 2,503 lb. at seven days to 4,295 lb. at 28 days, but at three months it was 3,741 lb. The strength of similar concrete at another port showed little change between seven days and one year. The strength of concrete with 600 lb. of cement per cubic yard was the same at one year as at seven days, although at three months the strength exceeded by 40 per cent. the strength at seven days. A decrease in strength after three months was common to all the defective concretes, although sound concretes with the same cement content increased in strength up to two years, and in some cases up to five years and ten years.

INCREASED TRAFFIC AT SOUTHAMPTON.

At the annual meeting of the Southampton Harbour Board, Alderman T. Lewis and Mr. C. E. Cotterell were re-elected chairman and vice-chairman respectively. Reporting as Chairman of the Finance Committee Mr. Cotterell said the volume of shipping using Southampton had increased from 8,000,000 tons in 1945 to just over 13,000,000 tons last year, and the opening of the oil refinery at Fawley at the end of this year should result in a sharp rise in the port's tonnage figures. There had been an increase of £4,200 in general revenue for 1950, but rising costs, which included larger payments to Southampton Corporation, accounted for increased expenditure of £2,743. The final result for 1950 was a balance of £36,638, carried to reserve and renewals account compared with £37,554 for the previous year.

Packaging for Export

Defective Internal Packaging now causes most Damage

By J. J. FERRIGGI*

Whilst a great deal has already been written about packaging, in my opinion not enough has been said about the conditions overseas, and what is even more important, the condition of the goods themselves when they arrive at their destination.

Obviously, for a packer to be in a position to know what type and method of packaging is necessary for a particular destination, he must first of all familiarise himself with the handling and climatic conditions en route to and in the country in question.

To ascertain these conditions a visit was paid in 1947 to various parts of the world, including the Caribbean area of South America, and in 1950 again visited the Caribbean to judge whether the action taken to improve packaging methods, which resulted from the information gained during my the earlier visit, was proving effective.

The object of this paper is to give details of the conditions in this area, which are representative of those in many other countries, also to give the details of the measures adopted to improve packaging, and what degree of success has been achieved. The countries visited were Trinidad, Venezuela and Colombia.

TRINIDAD

In Trinidad the main and only port capable of discharging ocean vessels is Port of Spain. This port is well organised with good, and as a general rule, ample storage facilities.

In common with most other tropical countries they have extremely high rainfall during the wet season, which, combined with a high relative humidity, can cause severe corrosion.

Handling in Trinidad, and transport conditions are generally speaking, quite good. The roads are equal to Class " B " British Category, and the railways, although they are somewhat limited in extent, are efficiently run.

Pilferage is a world-wide problem, and Trinidad is no exception, although a marked reduction in losses has been achieved by the energetic action taken by the Authorities in supervising port labour and operations.

VENEZUELA

My impression of Venezuela in 1947 was that due to rapid economic expansion the handling and transport facilities were unable to cope efficiently with the enormous volume of goods then being imported, with the result that goods were sometimes hastily discharged. badly handled and often stored in the open.

In this country also, tropical rainstorms and an extremely humid atmosphere make efficient anti-corrosive treatment essential.

In countries like Venezuela, where there are large undeveloped sparsely populated areas. transport facilities are bound to be somewhat primitive. Good roads exist, as a general rule, only in the main towns—the great majority are tracks which, due to the rains, great distances, and difficulty of maintenance, are often in an appalling condition.

Railways, for the reasons stated above, are not on an extensive scale, with the result that the majority of the goods required inland have to be transported by road.

Pilferage in this country, as elsewhere, is a serious problem, which is often aggravated by the fact that the goods can be easily taken from the packages that, due to their inadequacy, have been damaged in transit, even if only slightly. It should be borne in mind that damaged containers may have to travel several hundred miles inland after the damage has occurred.

COLOMBIA

The problem of packaging materials for export to Colombia is even more difficult than for other destinations. In my opinion shipments to this country, particularly to interior destinations, are subjected to some of the worst exposure and handling conditions that will be encountered anywhere.

Storage facilities at the ports are fairly good, although they are obviously not adequate, to judge from the quantity of goods of every description which were seen stacked in the open, outside the sheds.

In this country the climatic and transport conditions present an even greater packaging problem. Rainfalls of 8 inches in five hours are not an uncommon occurrence, so that a large part of the country is swampy and humid. These conditions, combined with the Andean Mountain ranges, made transport, until the advent of the aeroplane, extremely difficult.

The main means of transport is by boat on the River Magdalena, which is about 1,000 miles long, and is navigable by passenger and cargo boats, except during the dry season, between Barranquilla the main port in Colombia and La Dorada, a distance of about 550 miles.

As little or no maintenance work is undertaken on the river, coupled with the ever increasing demands of labour, some owners of the river craft are giving the Government notice of their intention to suspend navigation on this artery of Colombia's transport.

In this country of nearly half-a-million square miles there are about 2,200 miles of railways Unfortunately this railway system is composed of several sections, each in a different part of the country. Bogota the capital is not connected at the moment with any of the ports, except La Dorada, the port on the River Magdalena, but the Government is putting into effect plans to connect two existing sections, thus providing a link between Bogota and a port on the Pacific coast.

Open storage is common in congested ports, due to lack of transport, sudden import embargoes, etc. This example is the only storage space in a tropical South American country where humidity is high. Note lack of tarpaulins.

Of the 11,500 miles of roads in Colombia, only about 1,500 miles are usable at certain seasons of the year, owing to the lack of any permanent surface. The remainder of the roads are quite unmade tracks which are washed away, or at any rate impassable, during the rainy season.

PACKAGES WHICH FAILED

As a result of this first trip, during which I received details of well over a 100 complaints of bad packaging, every manufacturer was either visited or contacted and given copies of photographs relating to his own consignments.

It appeared from these complaints that in practically every instance, the failure of the packages was mainly due to the poor construction of the outer case or crate.

Improved methods were worked out, in conjunction with the manufacturers, bearing in mind that the Government request for increased exports to hard currency areas was, as stated earlier, prompted by our urgent need for dollars, not sterling from a British Insurance Company if the goods were lost or damaged, due to inadequate packaging.

After a period of three years, during which time we received over 300 complaints from our Oilfields and Refineries in all parts of the world, the position was reviewed by analysing the complaints received since 1946.

The percentages for corroded material from 1946 to 1949 decreased from 43% to 7¼%, those for damaged goods received inside damaged packages from 50% to 14½%. On the other hand

*Excerpts from a paper read at the Institute of Packaging (Midland Area)

Packaging for Export—continued

the analysis showed a notable increase in the proportion of complaints, for the same period, in respect of damaged material inside undamaged cases, viz., from 7% to 78¼%.

The only inference to be drawn from these figures was that although faulty case construction and corrosion was being eliminated, the battening, securing or cushioning inside the containers also needed improving.

SECOND TOUR OF INSPECTION

To ascertain if we had been working on the right lines, and to confirm that the above-mentioned theory regarding the unsatisfactory securing of items inside the packages was in accord with the facts, a second tour was made of the Caribbean in 1950.

At each of the places visited the picture appeared to be much the same. Whereas in 1947 all the countries in this, and most other areas, were importing an enormous volume of goods, due to their being unable to obtain supplies during the war years, they had in 1950 aparently passed the peak period Practically everywhere there were signs that the volume was slightly less, with the result that in most places handling was—well—not quite so bad as it had been, although, believe me, some would have been shocked to have seen cases from their works which had been very conspicuously marked "This side up"—"Glass"—"Handle with care"—in English, being thrown around by a Venezuelan or Colombian stevedore who didn't understand a word of our language

In general the defects noted, confirmed the need for much improvement in internal packing of goods, external marking and anti-corrosion precautions.

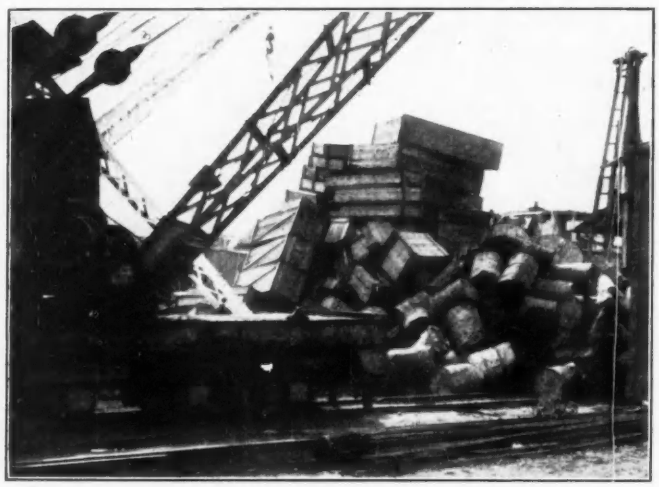
SIX QUESTIONS TO ANSWER

Having given a brief outline of the conditions in these countries, and the manner in which some materials are arriving at their destination, let us consider what information is required in order to design an efficient pack.

The first step should be to obtain the following data:

(1) The climatic conditions in the country to which goods are consigned.
(2) Any special packaging in view of the nature of the goods.
(3) Whether goods will be shipped on deck or transhipped en route.
(4) Unloading facilities at port of discharge.
(5) Handling conditions en route to final destination, not forgetting that the worst part of the journey may be after discharge from the ocean steamer.
(6) Packaging regulations of importing countries.

In deciding what action is necessary for climatic conditions, the main consideration must be the prevention of corrosion, if it is worth while sepnding a lot of money on development and production costs, it is only common sense to ensure that the goods are in good condition when they reach the user. To do this a specially



How goods are dealt with in another South American port. Complete absence of good handling and stacking.

The bases of cases need to be very strong, they are frequently subjected to great stresses.

compounded anti-corrosive should be employed wherever there are corrodable ferrous metal parts and surfaces.

Also, for the prevention of corrosion, or in fact for any form of deterioration through dampness, it is essential that the goods should be protected by using a good quality waterproof paper efficiently applied as a wrapper or liner.

The B.S.I. have in the Packaging Code, Sections which give the fullest information in this connection.

FRAGILE AND DELICATE PRODUCTS

The special packaging necessary for certain types of fragile equipment must be seriously considered. Cushioning with ordinary materials such as wood wool or straw are not satisfactory for such articles as large radio valves, etc., which should be anti-shock mounted in a lightweight crate, in which the valve should be visible.

Shipment on deck obviously calls for special attention to the waterproofing of the package, whilst transhipment means extra handling, with its attendant risk of damage, therefore, it is the duty of the packer to obtain this information in advance, and to take any additional precautions necessary.

Regarding the handling conditions to final destination, whilst some idea of the conditions which exist in the Caribbean area have been given, obviously it is impossible, in this paper to deal with each area in the world, but it is suggested that the manufacturer of packer should consult the buyer for information in this connection.

SOURCES OF REFERENCE

In connection with import regulations of the country to which goods are consigned, here also there are publications such as The International Mercantile Diary and Year Book, and Croners Reference Book for Shippers, which give much useful information on this subject.

The British Standards Packaging Code B.S. 1133, which is now being revised, will be found to give, in its various sections, which deal with practically every aspect of Packaging, most useful information on this complex subject.

There can be no doubt that in the future we shall need a further big expansion in Exports, which means that our overseas customers must be satisfied in every way with British goods on arrival at destination, for them to place additional orders in the U.K.

Only good quality products, well packaged, will achieve this end, therefore, it is up to each and every one of us to see that packaging does its job.

TRAINING FOR AUSTRALIAN DOCKERS.

The Australian Stevedoring Industry Board has opened a school at Sydney to train waterside workers in the operation of cranes and tow motors. The school will last about 10 weeks, and it is hoped to train about 100 men at a cost of £A2,000. When trained, the men will transfer to the mechanical branch of the Waterside Workers' Federation.

Navigation Locks on the Upper Mississippi

Some Recent Examples of Design and Construction *

By Major-General PHILLIP B. FLEMING (Retd.), Corps of Engineers, U.S.A.
Administrator of Federal Works, Washington; and
J. O. ACKERMAN, C.E., Corps of Engineers, U.S.A.

INTRODUCTION

THE purpose of this paper is to discuss briefly the newer practices in the design and construction of navigation locks. Much of the discussion is based upon the design, construction and operation of locks at Locks and Dams Nos. 1 to 9, in the St. Paul District of the Upper Mississippi River Waterway. These low head locks, constructed in the 1930's, are typical of recent design in the United States. The principal features of interest, in the order of their presentation, are: Location of Locks; Hydraulic Filling and Emptying Systems; Walls and Sills; Foundation Design; Lock Gates and Valves; Operating Machinery and Power Systems; Construction Methods.

The canalization of the Upper Mississippi River for nine-foot navigation, from Minneapolis, Minnesota, to the mouth of the Ohio River near St. Louis, Missouri, by the construction of Locks and Dams Nos. 1 to 26 was completed in 1940. A second lock at Lock and Dam No. 2, at Hastings, Minnesota, on which construction was started in 1941, was completed in 1948. Lock No. 27 at Chain Rocks Canal, St. Louis, Missouri, is now under construction by the St. Louis District. A new lock is also scheduled for construction in the future by the Rock Island District at the Keokuk Lock and Dam, Keokuk, Iowa. A new project for the extension of the nine-foot channel above St. Anthony Falls at Minneapolis, Minnesota, by the construction of locks at existing dams have been authorised and will be constructed in the future. The project as a whole is described more fully in References (1), (2), (3) and (4) listed at the end of this paper.

CONDITIONS AFFECTING DESIGN

Between St. Paul, Minnesota, and the lower end of the St. Paul district, below the mouth of the Wisconsin River, the Mississippi River meanders through a broad, level valley which is from one-half mile to three miles wide. The flood plane consists of alluvial deposits laid down in the gorge, which had been eroded in the sedimentary rocks of the region during the recession of the glaciers. Flood stages are low, with a range from extreme low water to extreme recorded high water of about 16 to 20 feet. The river had been contracted by wing dams constructed prior to 1930. The existence of towns, railroads, and agricultural developments within the flood plane made necessary the construction of comparatively low heads locks and dams. The locks below St. Paul have heads ranging from 5.5 feet to 12.2 feet. The only high head locks in the district are the twin locks completed in 1931 at Lock and Dam No. 1, St. Paul and Minneapolis, Minnesota.

Foundation conditions vary. With the exception of Lock No. 1, which rests on sandstone, all locks are founded upon alluvial deposits. The alluvial fill of the valley is clean sand overlain by fine-grained soil, at the sites of all locks and dams, except two, where thick deposits of clay and silt were laid down during glacial times when the river was ponded by natural obstructions.

GENERAL

To accomplish its purpose of facilitating navigation, a lock must be designed to fulfil the following requirements:

(a) It must be so located and constructed as to permit easy and safe entrance and egress by tows.

(b) Filling and emptying operations should be rapid, but must not produce disturbance of tows detrimental to their safety or to the safety of the lock.

(c) The structure must be of a type which will give trouble-free operation for a long period of years.

(d) It must be so constructed that it can be unwatered for the repair or replacement of parts subject to wear or corrosion, or exposed to injury.

The newer practices in the design of locks are not the result of radical changes and discoveries, but are the result of gradual changes made possible by the newer construction materials and methods, by the study of lock and dam structures by hydraulic models, and by the application of the principles of foundation engineering.

The standard lock design for the Upper Mississippi River was established by the Corps of Engineers after careful study of practice in Europe and experience with existing structures in the United States. Normally, the lock and the dam have been built in the same channel of the river with the main lock adjacent to one of the banks, as shown by Fig. 1. The initial contract for the structures built before 1940 ordinarily provided for the construction of a main lock 110 feet wide by 600 feet long and only the upper end, including the upper mitre gate, of an auxiliary lock, 110 feet wide by 360 feet long. The dam was built under a subsequent contract. Because of the increased length of tows now using the river, it is probable that new locks will be constructed 110 feet wide by 1,200 feet long where the site permits. One such lock (Lock No. 27) is now under construction in the St. Louis District. Another large lock may be constructed at Keokuk Lock and Dam in the Rock Island District. The guide-walls originally constructed at Locks Nos. 3 to 10 are 600 feet long upstream and downstream at the landwall. As a result of operating experience, the lengths of existing guide-walls are being increased. Guide-walls at new Lock No. 2 are 1,000 feet long. Guide-walls at the other locks in the St. Paul District will be extended to 1,000 to 1,200 feet. The lock width of 110 feet corresponds to the standard for the Ohio River and other navigable tributaries of the Mississippi River.

Lock walls in the St. Paul District are of mass concrete designed to be stable as gravity type walls. All walls and other heavy elements are built on piling. Concrete struts between walls assist in resisting lateral forces. The top elevation of the lock walls is above extreme high water, thus permitting the use of electrically operated machinery. All lock gates are of steel of the mitre type. The gate sills are sufficiently low to permit passage even if the pool upstream or downstream from the structure has been lowered in an emergency. The upper mitre sills of the auxiliary locks were constructed low enough to serve as passes for navigation during the extreme low water which occurred while the locks were under construction. The main lock at Locks Nos. 3 to 10 is filled through culverts extending the full length of both walls, controlled by Tainter type valves at the upper and lower ends, the water entering the lock chamber through small ports in the walls near the floor of the lock. The spacing of the ports has been either uniform or increasing from the upstream to the downstream end of the lock to produce more uniform filling. For the relatively low head locks of the project, the hydraulic design of the existing main locks has been entirely adequate. The layout of a standard lock and the upper bay of an auxiliary lock are shown in Figure 2. The new lock at Lock and Dam No. 2 and the locks now under construction depart from the standard layout because of foundation conditions and site topography.

LOCATION OF LOCKS

In the United States, tows consisting of a number of barges securely fastened together are pushed by high-powered towboats. The normal lengths of tows on the Upper Mississippi River in the St. Paul District range from 500 to 800 feet, with occasional tows up to 1,000 feet. During high-water periods, when the gates of the dams are raised completely, current flows which sweep across

*A Paper presented at the International Navigation Congress, 1949, in respect to Section I, Communication I, "New Development in the Design and Construction of Locks." Reproduced by permission.

Navigation Locks on the Mississippi—continued

the upstream approaches to some of the locks have been found to be detrimental to navigation. These cross currents are important because, on the Upper Mississippi River, navigation must pass through the locks at all river stages. Long guide-walls facilitate manœuvring tows into the locks. Hydraulic model tests have been conducted to determine the cause of cross currents at one structure. The remedial measures developed from the tests will include the construction of a wing dam upstream from the lock (somewhat similar to that shown in Fig. 1) extension of the guide-wall, and dredging of the approach to the dam.

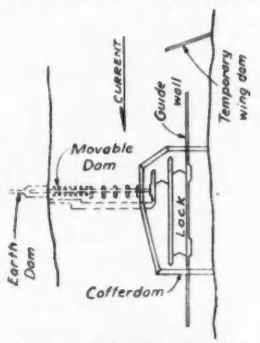


FIG. 1 - GENERAL PLAN
LOCK AND DAM

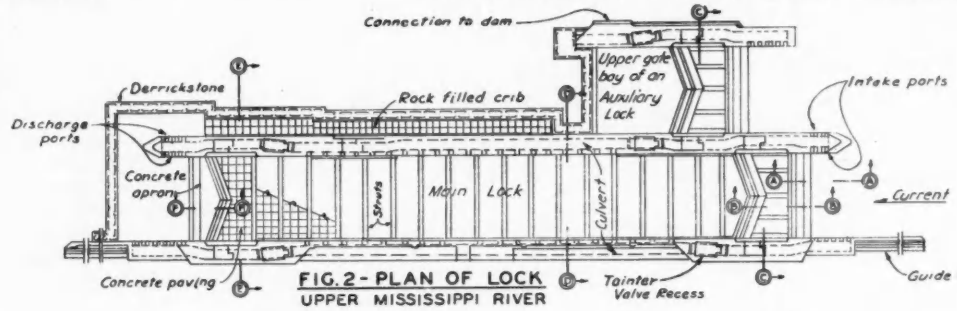
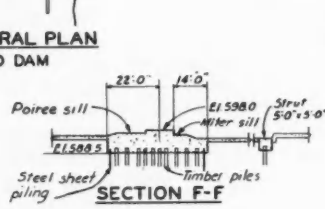
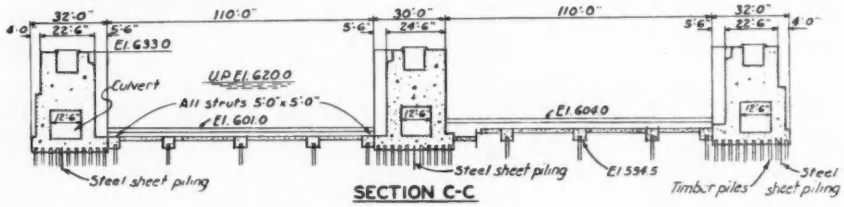


FIG. 2 - PLAN OF LOCK
UPPER MISSISSIPPI RIVER



SECTION F-F



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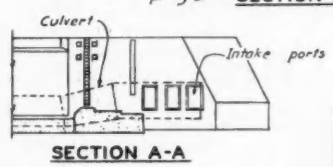
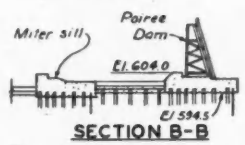


SECTION A-A



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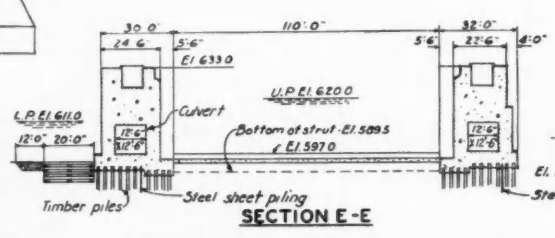
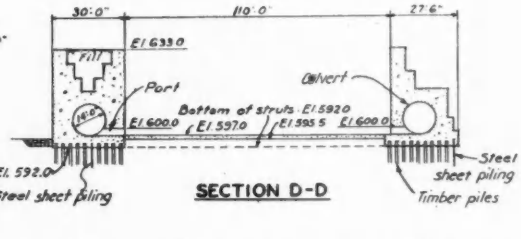


SECTION E-E



SECTION D-D

Practice in Europe, as well as in the United States, in locating the locks has varied. (References (5) and (6)). In cases where both the lock and the dam are located within one channel, some engineers have considered it desirable to locate the lock on the concave bank to minimise sedimentation in the lock approach area (Fig. 3 (a)). Locks have been located on the convex bank also, to improve flow conditions. Although the location of each structure is dependent upon the characteristics of the site and the design of the dam, operating conditions at several existing structures indicate that for a normal site the most advantageous arrangement of the structures may be as shown in Fig. 3 (b), with the dam located near the crossing. This arrangement produces the minimum change from the natural regimen of the stream, thereby minimising cross currents and sedimentation.

HYDRAULIC SYSTEMS

The hydraulic systems for filling and emptying locks can be divided into the following general types, depending on the locations of inlets to the chamber:

(a) Side filling.
(b) Bottom filling.
(c) End filling.

Side filling systems ordinarily utilise long culverts in the lock walls with ports connecting to the chamber. Bottom filling systems may require long culverts in the floor or long culverts in walls connecting to laterals. End filling systems may provide short culverts around or under the gates or discharge over, under, through, or between the gate leaves. Which of the above systems is most efficient in filling time and produces least disturbance of the tow must be determined individually for each project. The advent of hydraulic model testing has greatly increased the thoroughness with which such an engineering study can be made.

A hydraulic laboratory for the study of hydraulic problems of the Mississippi River project has been maintained at the University of Iowa, Iowa City, Iowa, by the Upper Mississippi Valley Division since 1929. This laboratory, operated under the supervision of the St. Paul District, has conducted tests of different types of filling systems for Mississippi River Locks and for other projects. (Reference (7)). A hydraulic laboratory is also operated by the St. Paul District at the University of Minnesota, Minneapolis, Minnesota.

The lock hydraulic systems utilising long culverts with discharge ports, described previously herein and shown in Fig. 2, have been shown by operating experience and model tests to be adequate for low head locks. This general type of filling system was used at all the low head locks of the St. Paul District. The system provided for the new lock at Lock and Dam No. 2 is virtually the same as shown in Fig. 2, except that ports on opposite walls are at staggered locations and are streamlined as shown in Fig. 5. Model tests for new Lock No. 2 included tests of short culverts around the gates. This system, however, was not adopted, not only because lockage was more turbulent, but also because the deep excavation increased construction costs and problems.

Model tests of high head locks (25 to 70 feet) have shown the most satisfactory system to be one with long culverts in the walls connected to transverse laterals in the lock floor, and with the discharge ports located in the sides of the laterals. These model tests have shown also that the intake of air into the culverts can be reduced greatly by locating all Tainter valves below lower pool elevation with the Tainter valves reversed, that is, with the gate arms in tension instead of compression (Fig. 10).

Model tests have been made of several locks in which Tainter or slide gates have been proposed for use as the upper lock gate, instead of the usual mitre gate. Tainter or slide gates permit dis-

Navigation Locks on the Mississippi—continued

charge of flood flows through the lock and normally reduce the size of lock walls. Filling by discharge over the gate has resulted in undesirable turbulence in the chamber of high head locks unless the system is augmented by discharge through a wall culvert with laterals. A system of this type has been incorporated in the design of Lock No. 27 and has been proposed for the St. Anthony Falls project.

The tests have shown that detrimental disturbance of tows is caused by wave travel and surging of the water in the chamber and that for all types of locks, beneficial reductions in turbulence without significant increase in total lockage time are achieved by using very slow initial rates of filling.

DESIGN OF LOCKS

Locks may be classified, according to wall construction, into the following types:

(a) Locks with gravity type walls constructed of mass concrete or reinforced concrete.

(b) Locks of the monolithic or dry dock type in which relatively thin reinforced concrete walls are constructed integrally with a thick floor slab.

(c) Locks in which much of the wall length is constructed of a material other than concrete, such as steel sheet piling.

Lock walls of the gravity type have been used most frequently in the United States. When adequately designed and on stable foundations, they are both efficient and economical.

Monolithic locks have been used in the past at locations where foundations are soft and where unit loads on the foundations must be reduced. This type of lock also can be used to advantage on foundations of soft erodible rock, such as soft sandstone, where piles cannot be driven and where loss of foundation materials by seepage would endanger the stability of the structure. The monolithic type of lock is economical only for narrow locks. For wide locks its use is limited to cases where unusual foundation conditions necessitate its use.

Locks in which the walls and guide-walls, except those portions of the walls restraining lock gates, are constructed of steel sheet piling or other low cost wall material, have been used for many small structures built in the last twenty years. Economy and freedom from failures caused by foundation movements have been their principal recommendation. Lock walls of this type are best adapted to low head locks in which filling and emptying is through the gate area. No structures of this type have been built on the Upper Mississippi River.

Gravity Lock Walls, such as those used in locks on the Upper Mississippi River, are designed for stability by the methods used for the design of masonry dams and retaining walls of gravity section. Care must be exercised to determine the critical loading conditions, particularly if reversals of load affecting the location of maximum foundation pressures occur. Ordinary computation methods suffice for walls on rock or cohesionless soil for which the compression is essentially elastic. As will be indicated in a later section, clay type soils in the foundation make necessary the study of additional factors.

The conditions of uplift must be examined for each loading analysis. Although flow analysis and other methods may be used to examine the conditions of loss of pressure head, it will ordinarily suffice to determine the percentage of head lost at a steel pile cut-off and to then assume uniform loss of head from the cut-off to the edge of wall or gravel drain. In the design of the walls of high head locks, uplift pressures in the concrete should be considered in the design. (Reference (9)).

Guide-walls or sections of lock walls which do not or may not have an earth fill against them should be designed to resist the impact to which the wall may be subjected. The magnitude of this impact is dependent upon so many factors and has received so little field investigation that definite values cannot be presented. For thin-walled sections or for locks in which the turbulences during operation will be great, it may be necessary to include in the loading conditions an allowance for hawser pull. Ice thrust also must be considered. (Reference 27.)

In retaining wall design it is ordinarily sufficient to analyze the stability of a section of the wall of unit length. In the design of a lock, however, where certain blocks or monoliths are subjected to concentrated loading, such as gate reactions, it is preferable to analyze each of these monoliths as a unit acted upon by external forces. By sub-dividing the structure into monoliths early in the design period, location of machinery, valves, etc., with relationship to construction joints is assured. Construction operations can be facilitated by the use of equal or nearly equal monolith lengths.

All locks which have been constructed in the St. Paul District, except Lock No. 1, have been founded on piles driven into sand. Wood piles have been used throughout at all locks, except new Lock No. 2, where steel H piles 110 feet long were driven under the gate monoliths.

Although batter piles have been used in Mississippi River locks to resist the lateral loads caused by backfill and water pressure, the more standard practice has been to distribute the load to the vertical piling of opposite walls by means of concrete struts between walls. Based on tests (References (14) and (16)), and experience with structures in service, the resistance of a vertical timber pile, restrained at the top, driven in clean cohesionless sand, has been established for design purposes at from 1½ tons to 4 tons per pile, depending upon the nature of the soil, the number and size of piles in the group and whether the lateral load is permanently or temporarily applied. In the St. Paul District the struts have been 5-ft. × 5-ft. in cross section, extending across the 110-ft. lock. Ordinarily the struts have been compression struts only, but in one case the struts were reinforced and anchored in the walls for tension as well. Struts are spaced so as to be midway between wall construction joints.

The Mississippi River locks are protected against abrasion by tows by steel wall armour in the form of horizontal strips cast into the concrete walls of the guide-walls and ends of the main lock walls. Waterseals of folded sheet copper with ends embedded in adjacent monoliths extend from the sheet pile cutoffs to above upper pool elevation at each vertical construction joint. Older locks which do not include the waterseals have displayed objectionable discharge of water from open construction joints as well as erosion of backfill near these joints.

Each wall and sill of a lock is a dam. This fact often is not considered in design. The foundation must be protected against the loss of soil resulting from seepage under the structure.

Floors used with gravity lock walls usually consist of thin blocks of concrete laid in checkerboard pattern, each block containing a weephole, underlain by a gravel drain.

Design of Monolithic or Dry Dock Type Locks. The cantilever walls and thick floor slab are designed to act together as a monolith. The floor slab can be designed as a beam resting on continuous elastic supports and loaded by a finite system of loads and moments. A relatively simple solution is possible if the lock foundation is such that the following assumptions can be made:

(a) That the deformation of the foundation is proportional to the loading; and

(b) that the beam follows the accepted theory of flexure.

Application of the method requires knowledge of the foundation modulus which cannot be determined from field or laboratory tests alone, but includes some factors dependent on judgment.

Application of the design method increases in difficulty with use of complex walls containing culverts and with floor slabs of varying thickness. Computations must be made for all different conditions of loading.

Basic information on this design method is presented in References (5), (6) and (8). The method is probably adequate for all cases where the behaviour of the foundation strata is essentially elastic. Where, however, the compression of the soil increases with elapsed time, other factors must be considered and the elastic analysis is inadequate. This subject will be discussed under "Foundations."

Steel sheet piling lock walls have not been designed in the St. Paul District and so are omitted from detailed discussion. The effect of corrosion in reducing the lock wall section should be considered in the analysis. For cohesive soils, foundations must be investigated to assure that the penetration of the sheet piling and

Navigation Locks on the Mississippi—continued

the tie-back anchorages is sufficient to prevent shear failure of weak soil formations.

Erosion adjacent to structures should be considered in design. The use of rock-filled cribs adjacent to the river wall downstream from the dam has been found effective in eliminating danger from high spillway discharges. Cross flow in the upstream lock approach may cause scour at the upper end of the river lock wall unless the area is protected by slabs or rock and brush mats. Experience has dictated the present practice of constructing a concrete slab at the downstream ends of locks to prevent erosion by the high velocity discharge during lock-emptying operations.

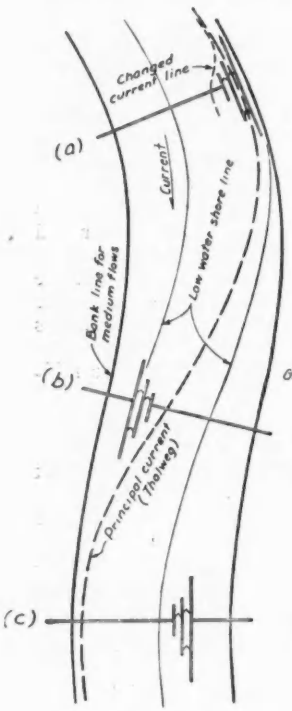


FIG. 3-LOCATION FOR LOCKS

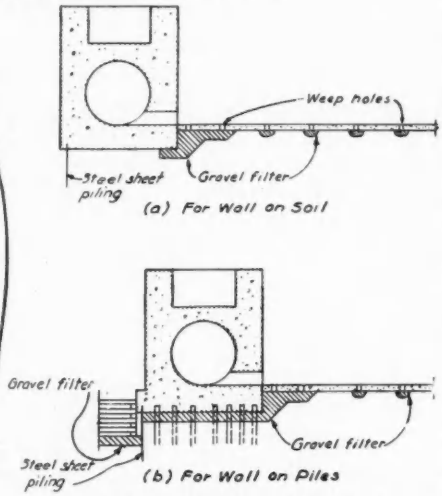


FIG. 4-DRAINS FOR WALLS ON PERMEABLE FOUNDATIONS

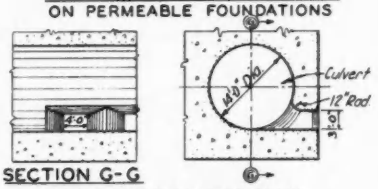


FIG. 5 STREAMLINED PORT

FOUNDATION DESIGN

Locks and dams must be constructed in locations where they best serve their purpose of facilitating navigation. Because of the heterogeneous nature of fluvial deposits, application of the principles of soil mechanics and foundation engineering to site selection studies and to structure design, is essential.

The entire lock and dam site must be thoroughly explored by boring methods which will accurately sample the various soil formations. If compressible soils are encountered, the collection and testing of undisturbed specimens is warranted. Borings should be driven to depths equivalent to the influence of the lock loadings, or to ledge rock.

The basic design of the lock will depend on the type of foundation material. Differences between the characteristics of sound rock, weak permeable rock, cohesionless sand and compressible silt or clay require very different treatment of structures founded upon them. The cohesionless sands of the Upper Mississippi Valley, generally free of compressible strata, dictated the use of pile foundations. Those structures founded on sandstones or on stratified clay have required different treatment.

Settlement of structures founded upon clay or silt or on cohesionless soils overlying fine-grained soils is caused by the consolidation resulting from the increased loading. Since the amount of consolidation of the silt or clay is a function of the increase in stress, non-uniform settlement is the usual, not the exceptional case for locks which, by their form, cause localised increases in stress under the walls and decreases under the lock chamber. The gate sections of locks can be misaligned by non-uniform settlement.

An example of the effect of lock settlement can be cited. Lock No. 2 in the St. Paul District, constructed before 1930, has shown the effects of differential settlement. This structure is founded on timber piles driven into a sand layer which overlies two layers of clays, the topmost of which is 60-ft. thick, and the lower 10-ft. thick. Fig. 6 shows a cross section through the lower gate bay and foundation of this lock.

All portions of the lock have settled, but the magnitude of this settlement has not been uniform. It is probable that the settlement would have been of little consequence, were it not for the fact that, in addition to settling, the land wall rotated backward at the top, causing some misalignment of the lower mitre gate. This backward rotation occurred not only in spite of, but because of the backfill behind the wall. The increase of stress in the clay is greatest under the backfilled area, dropping off toward the lock chamber. Inasmuch as the magnitude of the consolidation in the clay is a function of the increase in stress, greater settlement of the backfill and the back of the wall, than of the front of the wall, occurred. Computed curves of stress at the middle of the clay layer, which in simplified form illustrate the phenomenon, are shown at the bottom of Fig. 6, together with computed curves of settlement. The river wall of the same lock has settled also. It displays no rotation, however, because in the absence of backfill the increased loading on the clay layer produced by the wall is symmetrical. Detrimental movement of the land wall and misalignment of the gates have been stopped by the removal of a portion of the backfill behind the wall.

The construction of a new second lock at Lock and Dam No. 2 was begun in 1941, but interrupted by war. It was completed during 1948. This lock, located landward of the original lock, is unique in foundation design. All parts of the structure are founded on timber piles 20 to 25 feet long, except the four wall monoliths to which the mitre gate leaves are attached. These gate monoliths rest on steel H piles 110 feet long, which penetrate through clay and sand strata to rock. Movement of sections of the wall founded on wood piles is expected, but will not interfere with operation of the lock. Differential settlement between adjacent sections of the wall on different pile systems was compensated for by special treatment to reduce the effect of discontinuities of surface. Observations of settlement since 1943, when the lock concrete construction was completed, have shown differences in settlement of more than 0.2 foot. The structure is behaving as anticipated in design.

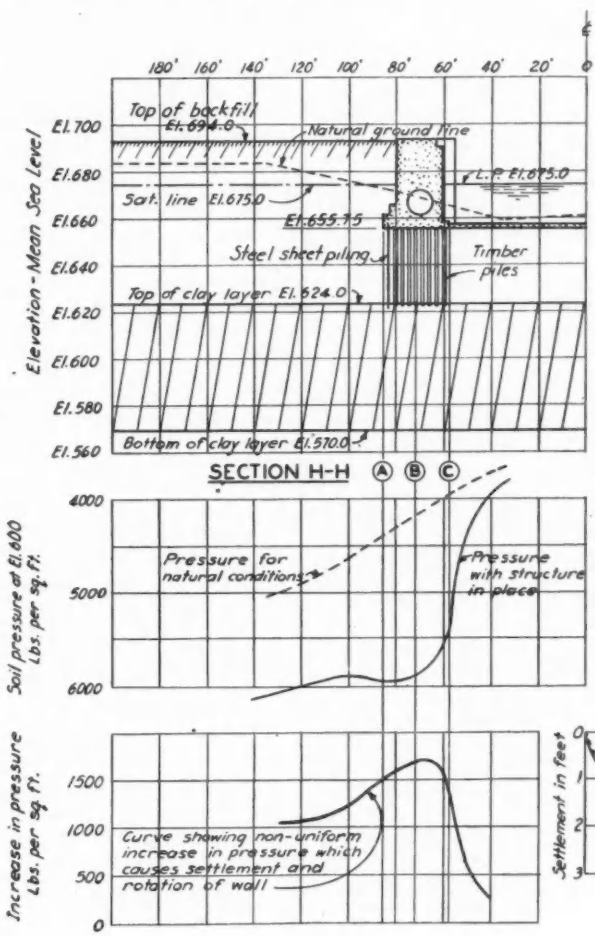
Monolithic Locks on Clay are subject to deformations similar to those described above, unless they are designed to withstand the changes in loading which accompany settlement of the clay. Preliminary design studies have shown this fact to be of importance. For the purpose of illustration, the same foundation condition as above, a layer of sand overlying a clay layer, has been selected. The moments in the monolithic floor slab can be computed by the elastic beam theory. This computation, however, can represent conditions only at the time when the structure is first placed in operation. As time progresses, settlement resulting from the consolidation of the clay will occur. The greater tendency toward settlement under the heavy walls and backfill of the structure will cause a redistribution of the soil reaction under the floor, tending to concentrate heavier loading under the middle of the floor and reduce the loading under the wall portions. Equilibrium will exist, only when the load transmitted to the soil by the structure produces a uniform pressure and settlement in the clay under the structure. If the total weight of the lock structure is equal to or greater than the weight of the earth excavated for the construction of the lock, and the weight per square foot of the backfill above the base of the wall is not appreciably different from the uniformly distributed weight of the lock section, the ultimate condition of equilibrium for the given case will occur when the soil reaction is distributed as a uniform load over the base of the floor.

If, however, the total weight of the lock is less than the weight of soil excavated, or if the weight of the backfill is much greater than the uniformly distributed weight of the lock, the case is not so readily analyzed. Fig. 7 shows a simplified approach to the problem by determining the pressure distribution in the clay under the structure. The magnitude and distribution of this soil reaction yields a greater moment in the floor slab than would result from

Navigation Locks on the Mississippi—continued

a uniform distribution. At the present time, this can only be determined approximately. Fig. 7 is very much simplified and at best only indicative of the importance of special analyses for monolithic locks on or overlying clay.

In the design of a monolithic type of lock underlain by clay, the effect of many factors must be considered. The natural loading under which the clay is stable, the relative weights of the structure and the excavation, the thickness of the floor slab, and the weights of backfill are factors of importance.



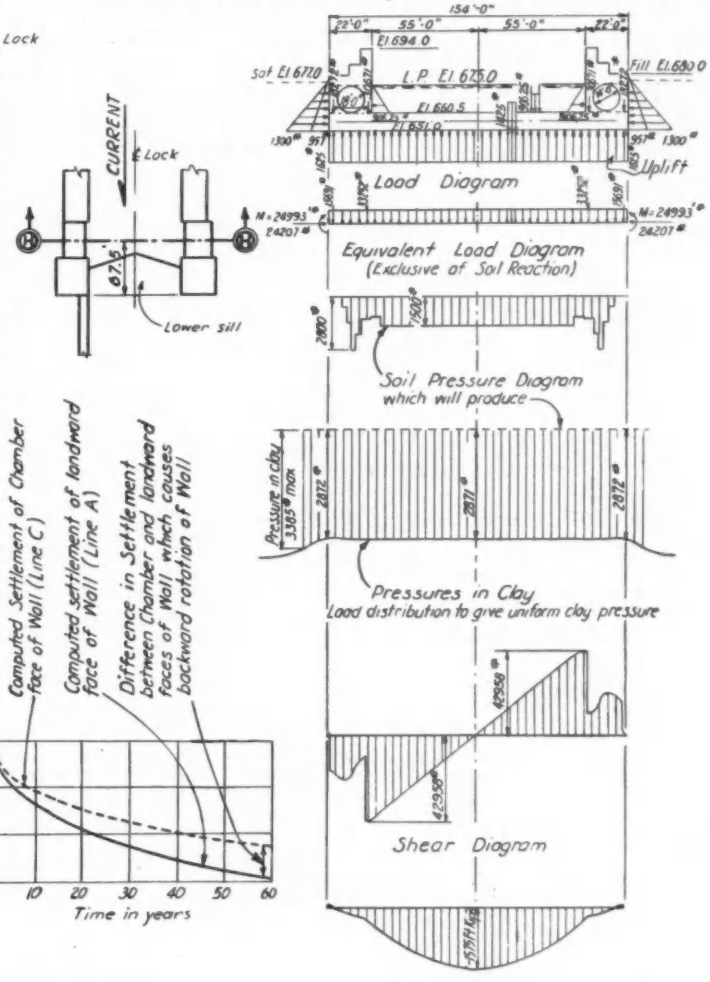


FIG. 6 COMPUTED PRESSURES AND SETTLEMENTS
GRAVITY TYPE LOCK OVERLYING CLAY

FIG. 7 DESIGN OF MONOLITHIC LOCK
OVERLYING CLAY

Pile Foundations may be necessary to serve one of the following purposes (References (13) and 14)):

(a) The transmission of load through a soft top stratum to a deeper, more stable soil.

(b) Compaction of a soil, the nature of which so permits.

(c) In a more or less unsuitable soil, the transfer of load to the soil deeper in the foundation where the soil is in a condition to better resist the increased load.

On the Upper Mississippi River, timber foundation piles designed for load bearing have served, incidentally, to compact the alluvial sand deposits of the foundation areas, which are naturally of low density because of their method of deposition. The compacting influence of driving foundation piles has been evident during the construction period, often causing noticeable settlement of the foundation area. (Reference (17)).

Foundation pile lengths were determined from driving and loading tests performed as a part of the construction contracts. Because the driving of single test piles does not show the effect of sand compaction, a group of 30 to 50 test piles was driven at each structure as a driving test, the spacings between piles being established to conform with the spacings proposed for the final structure. The order of driving was designed to permit study of the compacting influence of the pile driving. Selected piles were loaded with static loads to indicate the connection developed between the piles and the foundation material. (Reference (17)).

Batter Piles have been used by the St. Paul District for a number of structures. Design of batter pile systems has followed the method outlined by H. M. Hill in the discussion listed in Reference (15).

Security against Underseepage is of paramount importance in foundation design, if gravity lock walls and sills are to be safe not only for normal operating heads, but the higher heads which occur when the lock is unwatered.

Flow under a dam or lock wall on a permeable foundation is laminar and may be evaluated by various graphical and mathematical methods. The ability of the water to move sand is a function of its "escape gradient" at the point of emergence. The steel pile diaphragms driven around the perimeter of locks on permeable foundations, in addition to protecting against erosion, increase to some degree the length of flow path and tend to reduce the " escape gradient."

For locks at which the head is high when unwatered, or which are founded on permeable soils into which steel piles cannot be driven, additional or other methods of protection must be used. For locks on friable sandstone, the monolithic or dry dock type of

Navigation Locks on the Mississippi—continued

lock is an excellent solution. Inasmuch as large inflows to the lock chamber during lock unwatering can cause no damage, if the movement of the soil is prevented, the use of graded gravel drains or reverse filters at all joints or openings where water can emerge, offers an effective solution. Application of drains to masonry dam and earth dam constructions is now considered a standard and economical practice. Fig. 4 (a) shows diagrammatically a wall section and portion of the floor slab with graded gravel drain, which probably could be used with walls which rest directly on a permeable foundation.

When the structures are founded on timber piles, evidence from past construction projects has shown that the sand compacts and settles away from the base of the wall, leaving a void. The length of flow path is thereby shortened and the sand released from the restraint which would stabilise it. Fig. 4 (b) shows the layout for a filter which possibly could be used with pile foundations. In the cases of twin locks, filter protection may be necessary to prevent damage by cross flow between chambers. References (10) to (12), inclusive, contain information which is of value to the lock designer.

DESIGN OF LOCK OPERATING PARTS

The gates, valves, and operating machinery of the locks of the Upper Mississippi Waterway are essentially standard, except for size, for all the newer locks. The height of lock walls above flood elevation permits the use of electrically operated machinery, 440-volt alternating current being used. Of the two older locks in the district, Lock No. 1 is hydraulically operated and Lock No. 2 is powered by manually-controlled direct current.

LOCK GATES

Lock gates of all structures in the St. Paul District are of the mitreing type. Vertically framed gates are used at all structures except the high head locks, 56 feet wide, at Lock and Dam No. 1, where horizontally framed gates are used.

Practice in the United States utilises horizontally framed gates when the ratio of the height to the width of the gate leaf is about 0.7 or greater. The upper main girder of vertically framed gates and the series of horizontal girders of horizontally framed gates are designed as beams subjected to transverse and axial loading. The vertically framed gates have been designed for the normal operating pool acting on the gates together with an impact load of 120,000 pounds concentrated at a point on the upper girder. This impact factor is, of course, too small to protect the gate against a tow completely out of control, but does safeguard against failure due to a minor accident. For abnormal loadings such as absence of water below the lower gates, slightly higher working stresses are allowed. Torsional stresses caused by the water load developed on the gate by its movement between the recessed and the mitred position are taken into account. Prestressed diagonals now are used to resist torsional deflection and to assure that diagonals are always in tension. (Reference (25)).

The gates recently installed at new Lock No. 2 are of welded construction, using high strength low alloy steel to decrease weight and increase resistance to corrosion. All other gates in the St. Paul District are of riveted construction.

Moulded rubber water seals similar to those which have been found satisfactory on the Tainter and roller gates of the dams, have been used on the mitre gates recently installed at New Lock No. 2.

Valves for the hydraulic operating system have been constructed in the United States of many types, including Tainter, butterfly, Stoney and slide gate. In the St. Paul District one structure, a twin lock, uses Stoney gate valves hydraulically operated; another structure, vertical slide gates. Tainter gates of the normal type, in which the struts are in compression, were used at Locks Nos. 3 to 10.

Welded Tainter valves, reversed in direction, so that the struts are in tension (Fig. 10) were used in the new Lock No. 2. In addition to improving the hydraulic efficiency of the lock filling system, the reversal of the Tainter valves makes possible the location of hoisting cables or chains at the outer edges of the gate where interference with seals does not exist. Longer life and more effective operation are now being secured by the use of moulded rubber seals.

Lock Gate Operating Machinery on the Upper Mississippi River has been of the Ohio River mitre gate type, modified for the use of electrical instead of hydraulic power application. Alternating current electric equipment has the advantage of low cost, high efficiency, dependability, and permits the use of electric interlocks. The electric operation is not as smooth and shock free as the hydraulic operation. Sudden changes in the rate at which the gate is moved through the water develop hydraulic loads of considerable magnitude. This fact must be taken into account in the design of all units of the machinery, and particularly the foundation grillage embedded in the concrete. Operation should be controlled so as to minimise these forces, which are dependent upon the rate of change of gate speed and the submerged area of the gate. (Reference (25)).

Tainter Valve Operating Machinery consist of two electrically powered drums on which the cables attached to the bottom of the gate are wrapped. Because of the effect of alternate submergence and drying, and the difficulty of maintaining proper lubrication, it has been found desirable to use hoisting cables manufactured of stainless steel. These machines are simple and efficient. Motors of the operating machinery are wired for two speed control. For low head locks, no difficulty in securing submergence of the gate occurs. For high head locks, the use of a strut instead of hoisting cables is necessary to assure seal at closure.

CONSTRUCTION

All locks have been constructed under contract. Design plans and specifications were prepared by the Government. Contractors were permitted considerable latitude in the selection of construction methods. A brief summary of construction and inspection methods follows:

Cofferdams have normally been constructed prior to or during the winter period, with unwatering following immediately after spring high water. The usual types of cofferdam which have been used in the St. Paul District include box type construction with both walls of steel or with one wall of steel and one of wood, steel piling seals, and earth dams with protection against scour (Fig. 8). The choice in type has been dependent upon the contractor's experience, as well as the characteristics of the site. In one instance, the cofferdam design was the result of a model test by the contractor. (References No. (18) and No. (19)).

The behaviour of the cofferdams has indicated several points worthy of consideration. In the sand foundations of the Upper Mississippi River, the sheet piling, ordinarily cannot be driven deep enough or tight enough to secure complete cut-off of the seepage flow. It has been found that large sloping fills placed against the cofferdam walls are most effective in producing stability and eliminating danger from piping. At the corner of the cofferdam, where both scour and seepage flow are concentrated, less difficulty has been encountered when the corner is made a curve of comparatively large radius instead of a sharp angle.

The cofferdam which includes the lock structure, exclusive of guide-walls (Fig. 1), creates a constriction of the river channel which is conducive to scour along the upstream and riverward arms of the cofferdam. It has usually been necessary to place brush or lumber mats loaded with derrickstone or riprap at the upstream riverward corner of the cofferdam. With comparatively high flows occurring during the construction period, much difficulty may be caused by erosion during the driving of steel piling for the upstream and riverward cofferdam walls. The construction of a simple and cheap wing dam, as shown in Fig. 1, some distance upstream from the cofferdam location, was found by a number of the contractors to be of marked benefit in reducing scour. These wing dams were walls of steel piling or low brush and rock structures 300 to 400 feet long.

Several minor failures of cofferdams occurred. These were caused either by high river stages or by the instability of the sand foundation material produced by the removal of the sand fill adjacent to the cofferdam wall. Failures usually occurred at sections where security against under flow was low, because of a poor connection to an existing structure or because of the shallow penetration of the piling and absence of fill against the inner cofferdam wall. None of the failures caused serious damage.

Navigation Locks on the Mississippi—continued

Cofferdam unwatering has been performed by two general methods. The more common method utilised centrifugal pumps, with intakes located in previously constructed sumps for both the initial and maintenance unwatering. During the construction period, seepage water flowed to the pump sumps through ditches excavated for the purpose. The other method used lines of well points located inside the cofferdam walls, for the maintenance unwatering. With well points, completely dry foundation areas could be secured. In several cases where surface pumps were used for general unwatering, contractors utilised short lines of well points to unwater the local foundation area during placing of concrete.

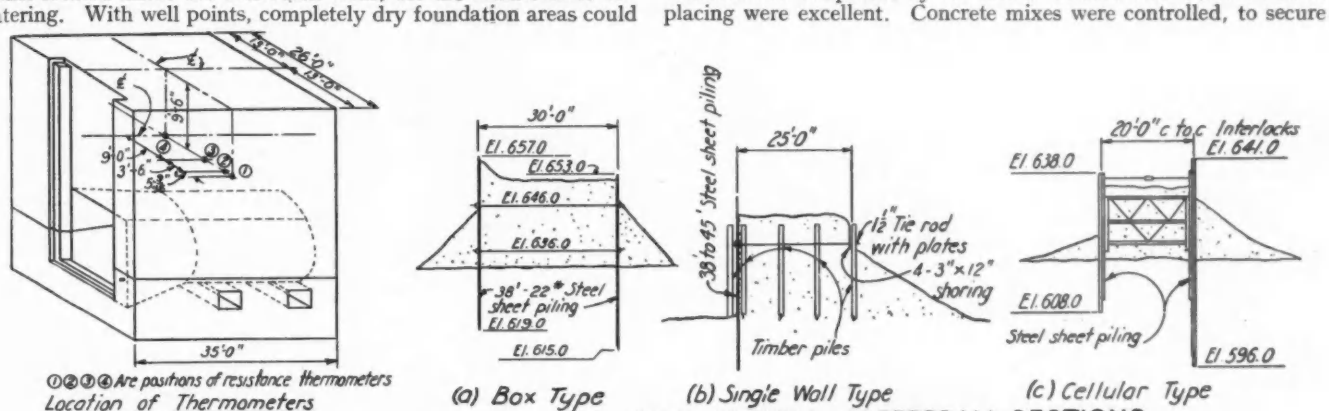


FIG. 8 TYPICAL COFFERDAM SECTIONS

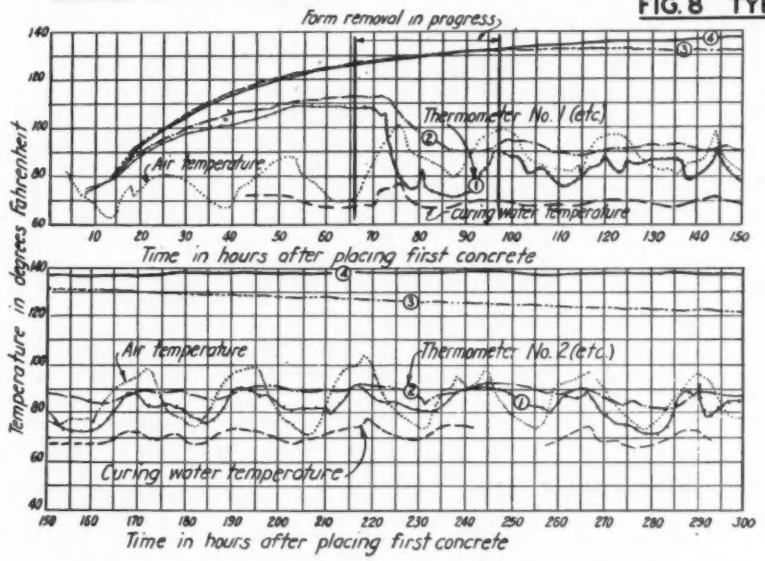

Form removal in progress
Thermometer No. 1 (etc.)
Air temperature
Curing water temperature
Time in hours after placing first concrete
Temperature in degrees Fahrenheit
Air temperature
Thermometer No. 2 (etc.)
Curing water temperature
Time in hours after placing first concrete

FIG. 9 OBSERVED INTERNAL CONCRETE TEMPERATURES
LOCK WALL

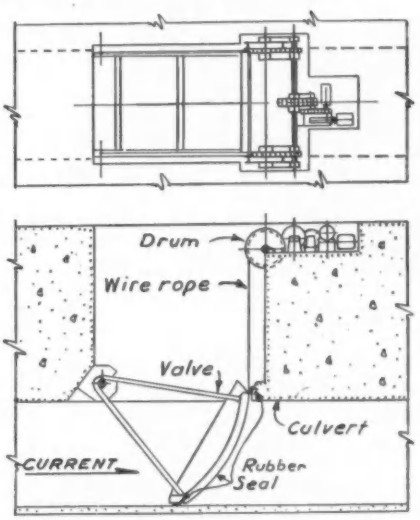


FIG. 10
REVERSED TAINTER VALVE AND MACHINERY

Pile Driving. Driving the timber piles was carefully inspected, particularly so in locations where the foundation was variable in character, containing boulders and slabs, or a hard layer to which piles are driven. Complete records of driving data were collected. Breakage of timber piles in areas of hard driving is much more common than is ordinarily recognised. Piles, shod or unshod, cannot be depended upon to penetrate thin layers of extremely hard foundation material such as gravel or hardpan. The intermittent pulling of timber piles, particularly those which decreased in driving resistance at the end of their penetration, is recommended.

The steel pile diaphragm under a lock, is depended upon to reduce the danger of damage to the structure. It is imperative, therefore, that piles interlock properly throughout their lengths and that operations be so conducted as to eliminate any chance of damage to the piles in driving. Extraction of piles which display extreme resistance to driving and interlock friction may show that the diaphragm was ruptured.

Concrete for the various structures was transported by various methods from the mixing plant to the forms. These methods included hauling by narrow gauge railroad or by trucks and pumping through pipe lines. (References Nos. (20), (21) and (22)). All concrete was compacted by vibration. Results with this method of placing were excellent. Concrete mixes were controlled, to secure the degree of workability most advantageous to placing by vibration.

With the purpose of reducing cracking caused by internal temperature, use of moderate heat of hardening cement was required and the maximum cement content for vibration-placed mass concrete was specified to be 4½ sacks of cement per cubic yard of concrete. The maximum water content was 6½ gallons per sack of cement. Reference No. 23 outlines some features of the concrete control. Although the thickness of the lock walls is comparatively small, it is sufficiently great when combined with rapid rates of placing, and the insulating effect of the forms to cause high internal temperatures. The construction procedure within economical limits was controlled to minimise the effects of internal temperature. Figure No. 9 shows the observed temperatures at several points in one monolith of a lock. Examination of these curves shows that a high temperature gradient can occur near the surface. Sudden changes in this temperature gradient caused by application of cold curing water or changes in atmospheric temperature may contribute to the cracking. (Reference (24)).

Navigation Locks on the Mississippi—continued

Recent practice of the Corps of Engineers requires the addition to the concrete of an admixture which entrains a controlled quantity of air. This entrained air has been shown by field and laboratory investigations to greatly increase the resistance of concrete to freezing and thawing. Air entrainment also increases the workability of the concrete and decreases bleeding. Air entrainment was used successfully during the construction of Lock No. 2 (Reference (25)).

Natural sand and gravel were used in the construction of all locks in the St. Paul District. The glacial gravels of that area are sound and free from minerals which react with cement. Examination of the structures has shown them to be free of defective concrete.

OBSERVATION OF STRUCTURES

As a result of experience with the older structures, the St. Paul District during and following construction makes periodic observations of the movements of lock walls and lock gates. This practice is recommended as a method of developing a fund of information which will be useful to the profession in guiding future design.

ACKNOWLEDGMENT

This paper, originally written in 1939, when the authors were stationed in the St. Paul District, has been revised in 1948 to include information on recent advancements in design practices. Acknowledgment is made of the great assistance which was given to the authors in their revision of the paper, by Colonel W. K. Wilson, Jnr., C.E., District Engineer, St. Paul District, Corps of Engineers, and to Messrs. H. M. Anderly, F. O. Borne, F. E. Mullen, E. Margulas, G. L. Lyon, A. H. Foehringer, and M. E. Nelson of the St. Paul District.

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IMPROVEMENTS TO THE CARTAGENA-CALAMAR CANAL.

The Colombian Government has signed a contract with the Standard Dredging Company of the U.S.A. to dredge the Dique Canal which connects Cartagena with Calamar. A dredger has already arrived and is expected to commence dredging within the next few days. Ultimately the canal will have a depth of 12 feet and a width of approximately 50 yards, and it is expected that the work will take about a year to complete.

NEW AMSTERDAM-RHINE CANAL.

During the last month leading industrialists and officials of Amsterdam made an official voyage along the Rhine in the motorship *Van der Steng*. The voyage, which involved sailing through a number of German, French and Swiss Rhine towns was undertaken in connection with the forthcoming opening of the new Amsterdam-Rhine canal which will bring the lower Rhine towns nearer to Amsterdam than to any other North Sea port. It is expected, that, following its opening, the goods traffic to and from Amsterdam will show a considerable increase.

PORT OF STANLEYVILLE EXTENSIONS.

Good progress is being made on the extensions to the inland port of Stanleyville, terminal of the main navigable channel of the Congo River, which stretches for 900 miles to Leopoldville. The extensions which were started some months ago, are planned to make Stanleyville one of the most modern ports in the Belgian Congo. The quays will be enlarged and the marshalling yards behind the port will be extended. Additional cranes are to be installed and the handling of cargo will be mechanised.

Manufacturers Announcements

British Industries Fair 1951
Details of some Castle Bromwich Exhibits

The Engineering and Hardware Section of the British Industries Fair, organised by the Birmingham Chamber of Commerce in collaboration with the Board of Trade, is being held at Castle Bromwich, Birmingham, from 30th April to 11th May. Many hundreds of firms are exhibiting, and among them are a number of our regular advertisers, who are displaying a wide range of their products, including the following:

ALLEN, EDGAR & CO., LTD.

Tool Steels, Die Steels, Steel Castings, Butt-Welded Tools, Deposit-Welded Tools, Twist Drills, Manganese Steel Axlebox Liners, Permanent Magnets, Circular Saws, Carbide-Tipped Tools, Toolholder Bits, Crushing and Grinding Machinery.

The most interesting exhibits include cast steel parts of excavating equipment for handling coal, gravel, peat, earth and stone etc. The trackwork department of the Company will show two specimen axleboxes lined with Manganese steel liners, and a small quantity of these liners of various shapes and sizes.

APPLEBY FRODINGHAM STEEL CO. (Branch of the United Steel Coys., Ltd.).

Rolled Steel Joists, Sections and Plates, also Steel Sheet Piling. Under the description " stainless steel " there are available a whole range of alloys designed to resist varying types of corrosion. These offer a range of materials differing completely in composition treatment and properties, in a way which is not always realised by the user who is proposing to solve a corrosion difficulty by employing " stainless steel."

BRITISH RAILWAYS.

British Railways, British Road Services, and the Docks and Inland Waterways Executive have provided an Information Bureau for the assistance of those requiring advice and help on any problem of Transport.

BROOM & WADE, LTD.

Compressors, Stationary and Portable Pneumatic Tools, which include Hammer Drills, Road Breakers, Pile Driving Head, Picks and Spades, Trench Pumps, Rammers, Vibrators, Crankless Air Motor-driven Winch and the New Lightweight Roller Chain Hoists which lifts 25 times its own weight.

Among other stationary and portable air compressors is the new type S.V.D. 606 portable patented Sleeve-Valve V. type, which is mounted on four pneumatic tyred wheels. The Compressor is driven by a Ruston 6 VPH six-cylinder Diesel Engine devolping 132 b.h.p. Starting is effected by a J.A.P. 600 c.c. Petrol Engine incorporated in the unit. This portable set can be seen in operation on this stand.

GEORGE COHEN SON & CO., LTD. (600 Group of Coys.).

Power Presses, Sheet Metal and Plate Working Machinery, Metalclad Woodworking Machinery, Hydraulic Presses, Electrolytic and Grey Cast Iron Powders, Jones Mobile Cranes, " 600 " Concrete Mixers.

Of special interest is the new Jones KL 66 six-ton Mobile Crane exhibited for the first time. This crane is designed to meet the requirements of high-speed for grabbing or operating with a magnet and great sensitivity of control for handling fragile merchandise and for the accurate placing of constructional units in building. The rated maximum load of 6 tons is taken at a 9-ft. radius and can be hoisted at 40-ft. per minute. The full range of Jones KL Cranes will be available.

CONVEYANCER FORK TRUCK CO. (Division of Electro-Hydraulics, Ltd.).

Diesel, Petrol and Electric-driven Conveyancer Fork Trucks, with Lifting Capacities ranging from 2,000 to 6,000 lb. Range of materials handling attachments include squeeze clamp, crane shovels, boom, rotating head, and side shift mechanism.

Model E2-20/3W is a new production. It is a battery electric three-wheel truck with a load capacity of 2,000 lb., a standard height lift of 9-ft. a travelling speed of 4½ miles per hour and can comfortably negotiate 10% gradients. It has a single unit driving mechanism which can be easily removed for servicing and removable panels give access to all components. The truck is specially designed for operation in minimum width gangways and its small outer turning radius gives it exceptional manœuvrability.

ENGLISH ELECTRIC CO., LTD.

Fuses, High Rupturing Capacity ; Fusegear; Instruments, Electrical; Platewarmers; Rectifiers ; Refrigerators ; Switchgear, Air Blasts; Transformers, Distribution; and all types of power Generation Equipment.

GENERAL ELECTRIC CO., LTD.

Everything Electrical for the complete equipment of electric power stations including Turbo-Alternators, High, Medium and Low Tension Switchgear, Control Boards, Transformers and Distribution Equipment, Materials, Handling and Conveying Plant, etc.

This stand is divided into two parts, one of which is devoted to turbo-alternators and coal-handling plant, and the other to certain designs of indoor switchgear. A working model of a Frazer and Chalmers Marshall Side Discharging Wagon Tippler is shown, operating for demonstration purposes, in a closed circuit with a system of electromagnetically-operated vibrating feeders. Dominating the whole stand is a 33 KV, 1500 MVA duplicate busbar, heavy-duty metalclad unit for main power station service.

HUNSLET ENGINE CO.

Hunslet Diesel Mechanical Locomotive together with full range of photographs and catalogues showing the complete range of Hunslet Steam and Diesel Locomotives of all sizes and types.

KELVIN & HUGHES (Industrial), LTD.

The exhibits on this stand include flowmeters (square root and linear), Flue-Gas Analysis Equipment with Lossmeters, Pyrometers, Electronic Temperature Controllers, Draught Gauges, Supersonic Flaw Detectors, Dynamic Strain Recorders, and other Instruments for Industry.

R. H. NEAL & CO.

Latest models of Neal's Mobile Cranes including the New Type " R " 10-tons capacity at 11-ft. 6-in. radius, with 30-ft. jib, fully mobile without outriggers, mounted on eight pneumatic tyres, power assisted steering. A number of other models are exhibited which are available mounted on lorries, or on caterpillar crawlers.

PRIESTMAN BROS., LTD.

The Priestman 3/8 cu. yd. " Wolf " and 1/2 cu. yd. " Panther " Excavators will be shown with a range of attachments. Also representative types of Grabs for Excavation, Material Handling, and Ship Discharging.

RANSOMES & RAPIER, LTD.

Rapier Excavators, Walking Draglines, Standard Mobile Cranes, Super Mobiles, Shop Truck Cranes, Fork Lift Trucks, Tilting Mixers, Trailer Mixers, Pan Mixers, Self-Priming Pumps, Muck Shifters, Sluice Gates, etc.

Among the exhibits is the Rapier 8 Super Mobile Crane, which was originally designed to meet the demand for mobile dock cranes capable of handling loads up to 8½ tons, with easily extendible jibs for handling lighter loads at heights and radii up to 50-ft. This crane is available with either short, medium or long jib extensions. The drive is petrol electric or Diesel Electric with variable voltage control for hoists, derrick, slew, travel and steer motions. It has a full circle slewing superstructure and is mounted on pneumatic tyres.

RANSOMES SIMS & JEFFRIES.

The exhibits of this firm will include an MG Tractor, a Bulldozer, a Spray Pump and a number of agricultural tools and implements.

THOMAS SMITH & SONS (RODLEY), LTD.

Smith " 21 " Universal Excavator, and Smith Super " Ten " Universal Excavator. These excavators are manufactured in several sizes with bucket capacities of 8 cu. ft., 3/8 cu. yd. and 3/4 cu. yd. Easily adaptable for all digging duties as face shovel, trencher, skimmer, dragline, crane, grabbing or piledriver. Front end equipment is quickly interchangeable on site. Range of standard diesel locomotive cranes are in sizes to lift 3, 5, 7½, 10 or 15 tons

Manufacturers Announcements—continued

or can be made to specifications as required. Range of mobile cranes also produced, mounted on road wheels or crawler tracks.

STOTHERT & PITT, LTD.

This firm is exhibiting concrete batching and road finishing plant. Batching and mixing plant with diesel or electric drive, one or two mixers (mixed batch capacity 28 cu. ft.), cement elevator, and 3, 4 or 5 compartment aggregate storage hoppers of capacity 40 to 100 cu. yds. Concrete mixers include a portable model of mixed batch capacity 7 cu. ft., with loader, syphon tank and diesel engine and fitted with power-operated shaker gear for loader, skip and spring-borne truck. Petrol engine, petrol-paraffin engine or electric motor drive can be provided as required.

THOS. W. WARD, LTD.

Photographs and descriptive matter of the T.W.W. Group's Heavy Industrial Activities, including Shipbreaking, Iron and Steel Producing, Scrap Production, and Civil, Mechanical and Electrical Engineering.

Monotower Crane for the Tyne

At South Shields, the Tyne Dock Engineering Co., Ltd., have installed a "Butters" four-motor type, 15-ton electric Monotower crane, designed, constructed and erected by Messrs. Butters Bros. & Co., Ltd., of Glasgow. The following table shows the speeds attained by each motion:

	B.H.P. of Motor.	Load Tons.	Speed Ft./Min.
Main Hoist ...	55	15	30 slow gear.
		5	100 fast gear.
Aux. Hoist ...	30	2	126
Derricking ...	60	15	50
Sluing	30	15	300

The steel-built supporting tower is 56 feet high, erected on a reinforced concrete foundation, and the revolving steel-built mast is supported at the base in a double row ball race with a series of horizontal anti-friction rollers which run on an internal pressure ring securely fitted to the top of the tower.

The jib introduces aluminium alloy sections, a new feature for this type of crane. It is 160-ft. long and is capable of making the following lifts:—

15 tons at a radius of 95 feet.
12 tons ,, ,, ,, ,, 108 feet.
10 tons ,, ,, ,, ,, 116 feet.
7 tons ,, ,, ,, ,, 128 feet.
5 tons ,, ,, ,, ,, 138 feet.
4 tons ,, ,, ,, ,, 150 feet.
3 tons ,, ,, ,, ,, 160 feet.

It is constructed in five sections, the bottom section in rolled steel, and the remaining four in aluminium alloy. The mechanical properties of this alloy are as follows:—

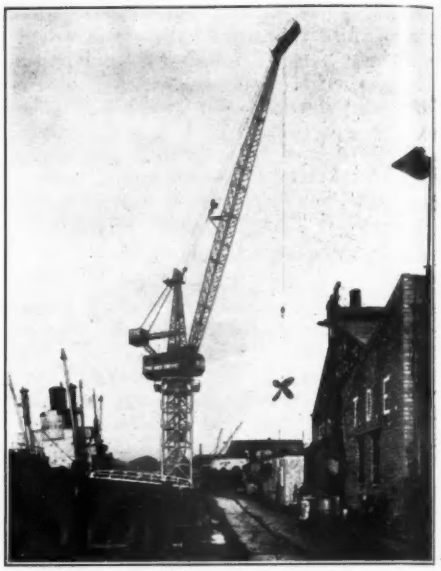
0.1 per cent. proof stress: 21 tons/sq. in.
Tensile stress: 27 tons/sq. in.
Elongation on 2 inches: 10 per cent.

The jib is 6 feet deep and 7 feet 3 inches wide at the centre, tapering to 20 inches deep at each end on elevations.

Four equal angles of 6-in. × 6-in. sections form the main members. The bottom members are $\frac{3}{8}$-in. thick throughout, the top members $\frac{1}{2}$-in. in the three top sections, and $\frac{5}{8}$-in. in the two bottom sections.

The elevation bracing angles are of 3-in. × 3-in. × 5/16-in. angle section alloy. The plan bracing consists of a 3-in. × 2$\frac{1}{2}$-in. × 5/16-in. angle section alloy crossing with a 3-in. × $\frac{3}{8}$-in. flat alloy section. Diaphragm bracings are fitted where required.

The jib is riveted throughout with $\frac{7}{8}$-in. diameter steel rivets, the rivet holes being



primed with zinc chromate base paint before riveting and all scale removed afterwards.

It will be appreciated that a considerable saving in the jib weight has been attained by using the light alloy metal, which means that less power is required to lift the jib under working conditions.

FOR SALE.

SELF-PROPELLED "AIRVEYOR".

The Port of Bristol Authority has for disposal One Self-Propelled "Airveyor" portable pneumatic grain elevator, by the Fuller Company, U.S.A. The Plant comprises a Rootes blower of 20-40 tons per hour capacity, driven by a 115 H.P. "Caterpillar" Diesel engine and mounted on pneumatic tyres as a trailer unit coupled to a General Motors Towing Unit powered by a 6 cyl. G.M. petrol engine, together with a quantity of 8-inch steel and flexible piping. Applications for forms of tender to be made to the Engineer-in-Chief, Port of Bristol Authority, Avonmouth Docks, not later than 31st May, 1951.

53 NEW STEEL PLATE RIVETED DREDGER-BUCKETS. Cap. 23 cu. ft. Apply to: Box No. 122, "The Dock & Harbour Authority," 19, Harcourt Street, London, W.1.

APPOINTMENTS.

GREAT YARMOUTH PORT AND HAVEN COMMISSIONERS. ENGINEER.

Applications are invited for the position of Engineer to the Commissioners.

The duties, inter alia, include the control of works of reconstruction, maintenance and repair of Piers and Quays; maintenance of Plant, etc.; and the survey of Inland Rivers.

Salary according to qualifications.

Applications with testimonials should be sent to the Clerk to the Commissioners not later than 2nd June, 1951.

21, South Quay, Great Yarmouth.

L. A. COLEBROOK, Clerk.

HEAD, WRIGHTSON & CO., LTD., Teesdale Iron Works, Thornaby-on-Tees, require Design and Detail Draughtsmen for dock gates and caissons. Apply to Personnel Manager.

ADMIRALTY (CIVIL ENGINEER-IN-CHIEF'S DEPARTMENT).

Immediate vacancies exist for Leading Architectural and Civil Engineering Assistants in the Drawing Offices at the following establishments: Pinner (N.W. London), Leeds, Glasgow, Lossiemouth (N.E. Scotland) and Arbroath (N.E. Scotland). In addition there are likely to be vacancies at all Admiralty Establishments in this country and Northern Ireland with opportunities for service in Admiralty Dockyards overseas.

Applicants must be competent draughtsmen and designers with experience in some of the following types of Building and Civil Engineering Structures and Works.

Structural Steelwork, Reinforced Concrete, Dock and Harbour Works, Accommodation, Residential, Office, Store and Factory Buildings, Oil Fuel Tanks and Pipe Lines, Airfield Construction and Maintenance, Rail, Road, Water Sewerage and Heating Services, etc.

The salary range is £570 p.a. × £20 p.a.—£675 p.a. The rates quoted are "London" rates and are slightly lower in the provinces. In addition appropriate rates of Foreign Service Allowance are payable at Stations abroad.

The appointments are temporary.

Applications should be made giving full particulars of experience to the Civil Engineer-in-Chief, Admiralty, Chamberlain Way, Pinner, Middlesex.

CCB.47.FS.

ASSISTANT CIVIL ENGINEER required for a position on the staff of the Resident Engineer on a large Civil Engineering Contract in the north-west of England. Applicants should have a good general knowledge of Civil Engineering work, including both construction and design. The work offers exceptional opportunity of gaining experience for a young engineer and the probable duration of the contract will be two/three years. The salary will be in accordance with qualifications and experience. Applications, giving full particulars and stating the earliest date on which the appointment can be taken up, should be addressed to: Box No. 123, "The Dock & Harbour Authority," 19, Harcourt Street, London, W.1.